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## The Cannon Falls Hydro-Electric Development

Designed for An Ultimate Capacity of Three Thousand Horsepower

THE accompanying illustrations on this page show the concrete dam of the Northern States Power Company under construction and the concrete power house completed. This development is located on the Cannon River two miles west of the town of Cannon Falls, Minnesota. The dam is of concrete construction and rests upon a solid rock foundation. It measures 933 feet in length with concrete buttress construction 773 feet long. The length of the spillway is 430 feet, and the width of base including apron, 90 feet. The spillway crest has an elevation of 151.5 feet, the tail water being 96 feet and the flashboards 154 feet, while the flow line is 155 feet.

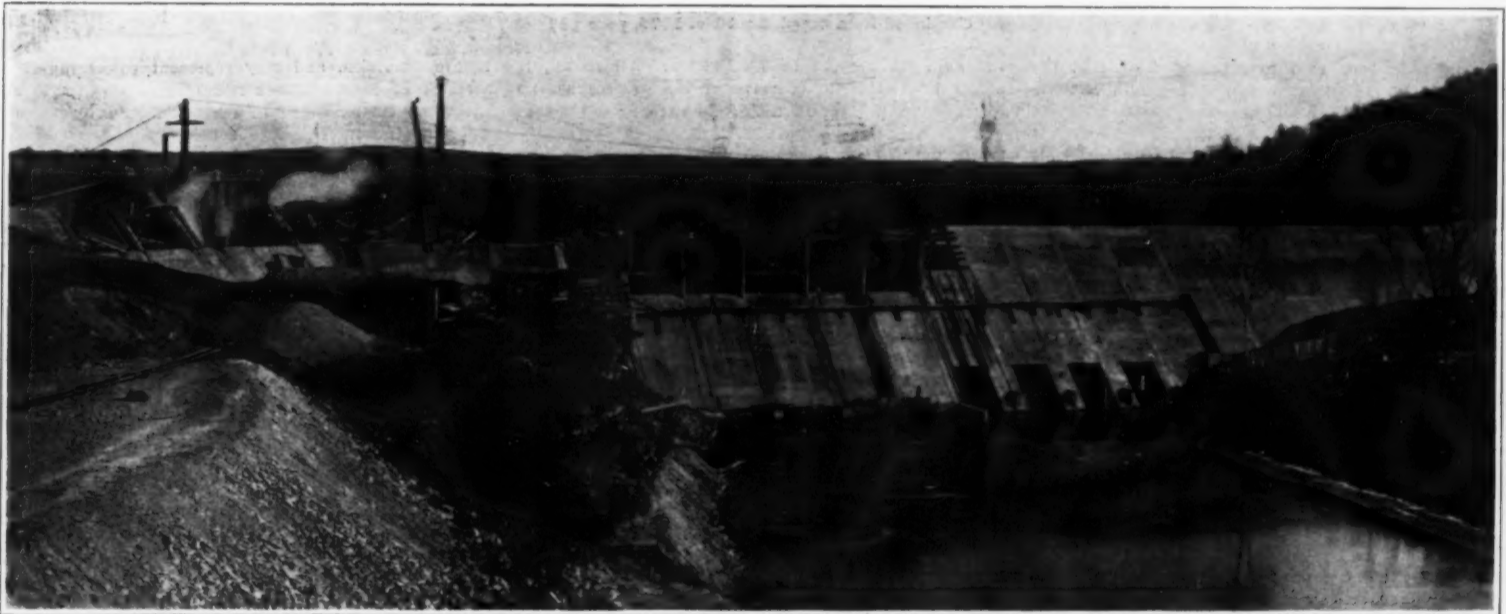
The maximum hydraulic head is 59 feet and the ordinary operating head 58 feet. The units are designed for a minimum head of 45 feet, thus allowing

a 13-foot draw down of the reservoir. There are four 7x5 sluice gates, which, in conjunction with the spillway, will care for a flood discharge of 15,000 second feet. About three quarters of a mile west of the dam is a dike 2,000 feet long with a maximum height of 16 feet. It is built of earth embankment riprapped on the reservoir side and sealed with a concrete core wall. The storage water reservoir contains approximately 2,010 acres, which, with a 10-foot draw down are estimated to provide 60 days' storage. The power house, constituting part of the dam, is 92 feet long, 38 feet wide and 29 feet from floor to ceiling. Water wheels are arranged to discharge into a tailrace which is part of the river channel.

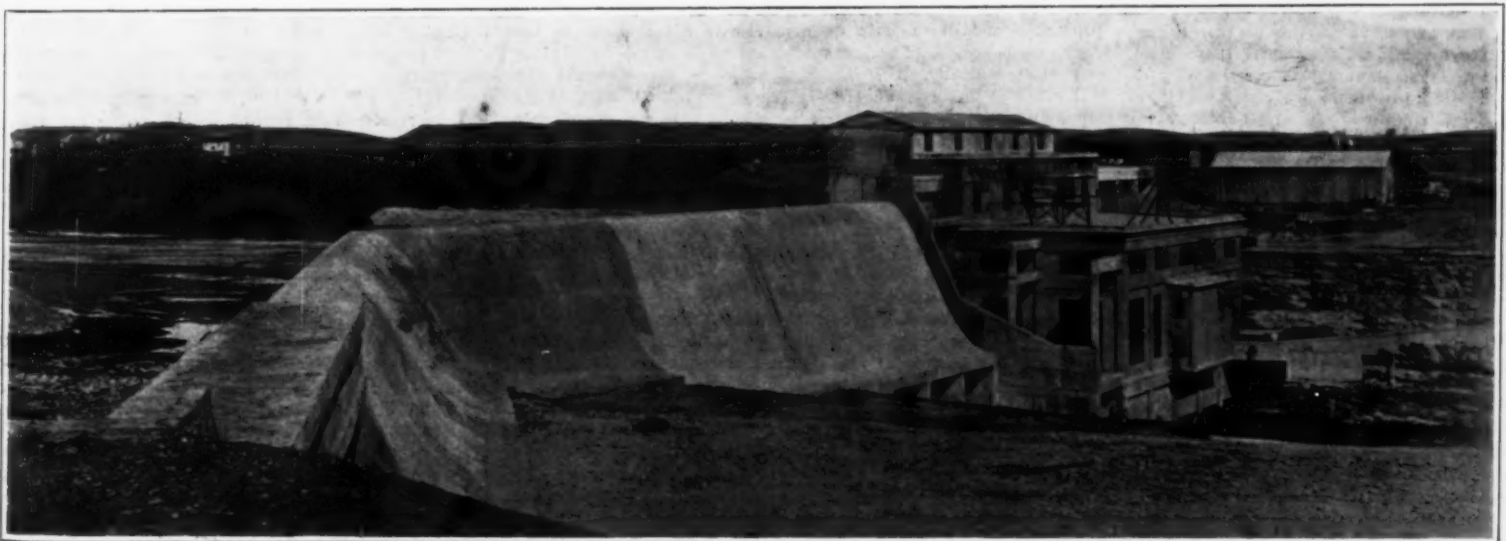
In the power house there are two main units installed, each being a horizontal double spiral case,

central discharge water wheel, with a capacity of 750 horse-power and operating at 300 revolutions per minute. Each wheel is direct connected to a 550-kilowatt, 60-cycle, 3-phase, 2,300-volt generator, with a six-ton flywheel mounted between generator and water wheel. Each generator has a direct connected 14-kilowatt exciter.

A separately driven exciter unit consisting of a horizontal double discharge, 60-horse-power water wheel is direct connected to a 35-kilowatt, 125-volt exciter, operating at 600 revolutions per minute. While at present only two main water wheel units are installed, provision has been made for the installation of two additional main units and one additional exciter unit. The present capacity is 1,500 horse-power, while the ultimate capacity is 3,000 horse-power.



The Concrete Dam in Construction.



The Concrete Power House Completed.

The construction of this dam required 17,000 cubic yards of earth excavation, 21,500 cubic yards of rock excavation, and 16,400 cubic yards of reinforced concrete, while in the dike there are 4,000 cubic yards of earth embankment, 750 cubic yards of concrete, and 300 cubic yards of excavation for the core wall.

A transmission line runs between the city of Mankato and the Blue Earth River dam, a distance of ten and one-half miles, and another line has been erected from the Cannon Falls dam to the city of Faribault, a distance of thirty and one-half miles. These transmission lines are now operated at 33,000 volts, but insulators and insulation have been designed so that operation can be had at 60,000 volts without any charge except the connection of transformers. The insulators are placed so that wires are located with six-foot centers and are mounted on a special type steel cross-arm, known as the "Bylesby wishbone arm." A ground wire has been installed above the transmission wires. On lower cross-arms a telephone circuit has been strung, interconnecting the power houses and sub-stations.

Substantial modern brick sub-stations two stories in height have been erected in Mankato, Faribault, and Northfield, the principal equipment consisting of a suitable transformer for reducing the voltage from the transmission lines for commercial distribution. It may be mentioned that the electrical apparatus at the power houses and sub-stations is protected with the latest type oil switches and lightning arresters, together with modern switchboards for the control of distributing circuits. The system has been planned and sub-stations designed so that the transmission

lines may be extended from the sub-stations at Faribault to the sub-station at Mankato, thus connecting the two developments.

Faribault has an estimated population of 9,000, and is the capital of Rice County, Minnesota. It lies south of St. Paul, between the cities of Mankato and Northfield, in the richest agricultural section of the State.

Three large institutions, those for the deaf, blind and feeble-minded, are located here. The city is the home of Shattuck Military Academy, St. James School, St. Mary's Hall, Seabury Divinity School, and Bethlehem Academy.

The city in 1910 made a ten-year contract with the Consumers Power Company for an ornamental street lighting system in the business district. This has been installed and is now in operation, making Faribault one of the best lighted cities in the State. The entire electric light and gas business of Faribault is conducted by the Faribault Division of the Consumers' Power Company. Formerly two central station companies existed, one of them having the gas business as well.

It may be stated that both electric properties were purchased prior to assumption of control by the present management, February 1, 1910. The less efficient of the power stations has been dismantled and the other power station remodeled and improved. The electrical demands of Faribault are now supplied from the hydro-electric development near Cannon Falls, but it will be necessary to maintain a steam auxiliary station and the remodeled plant will serve this purpose. A high tension sub-station has been erected. Last year

the electric station had a total connected load of 1,380 kilowatts, 337 kilowatts of which represented the power load. There were 1,067 electric consumers and 27.1 miles of rehabilitated pole line. Eighty-seven municipal arc lamps, 162 municipal incandescent lamps, and 106 ornamental curb lighting standards were served.

The steam electric generating station at Mankato was outgrown some years ago. For this and other reasons the electrical development of the city is not nearly as large as it should be. The present station has an installed capacity of 1,100 kilowatts. At the present time on account of the completion of the hydro-electric project at Rapidan Mills, an adequate supply of electricity for the Blue Earth River is now at hand. The steam plant, at which a large high tension sub-station has been erected is now maintained as an auxiliary station to be held as a reserve. Service from the Blue Earth water power plant was available about May 1st, 1911.

It is claimed that despite adverse conditions, new business efforts during the summer and early fall increased the electrical business approximately 20 per cent. Municipal street lighting is done under favorable contract with the city. Negotiations are in progress looking toward the installation of an ornamental street lighting system in the business district and the pumping of the municipal water supply by the Consumers' Power Company. It is maintained that there is room for 1,500 horse-power electric power consumption, and it is expected that during the next few months the consumption of electric energy at Mankato will be doubled.

## The Psychology of Light—II.\*

### The Subjective Aspect of Optics

By Prof. R. S. Woodworth

Continued from Supplement No. 1876, page 387

Enough has been said to make it clear that the relation between color tone and wave-length is nothing universal, uniform and necessary. The relation is in reality extraordinarily complicated; and to give some rational interpretation of this complexity is the province of physiology with its color theories. Between the physical light and the system of color sensations intervenes the eye, and especially the retina, a receiving and transforming organ and something in its manner of transformation must, probably, be the cause of the intricate relations between the physical stimulus on the one side and the color sensation on the other. Without attempting to discuss the merits of the several rival theories of color vision, no one of which, probably, is fully adequate, the theory which commands most adherence from psychologists at the present day may be considered; that is, the theory put forward by Hering. No attempt is made here to follow Hering in all details, nor to keep his ideas distinct from those of other contributors to the theory.

In the first place, the mechanism by which the retina transforms light into nervous impulses is, in all probability, either chemical or electrical or, most likely, electrochemical. The photic stimulus, impinging on the rods and cones of the retina, must arouse in them some movement of molecules or atoms, some migration of ions, some rotation of electrons; and this movement must in turn start the somewhat similar movement in the nerves which is propagated to the brain. Apparently there must be present in the retina some substances sensitive to light, such that minute motions are generated in them by the ethereal vibrations. Whatever the exact nature of this electrochemical motion may be, it must apparently be conceived as reversible. The electrons must be capable of rotating in two opposite directions, or the ions of migrating to and fro between two compounds, or the molecules of disintegration and reintegration similar to what is observed in the action of certain enzymes. The need for some such assumption is partly to account for the recovery of the retina after activity, partly to account for the positive character of the sensation of black, and partly to explain the opposition between certain rays and certain other rays in their action on vision.

Black is not, psychologically, a mere absence or negation, but is as positive as any other visual sensation. A mere absence of visual sensation is not black, but—simply nothing at all, as for example, the impression derived from a ray which falls on the blind spot or outside of the limits of the field of view. Moreover, black, or at least dark, is as essen-

tial as light for the uses of vision. All in all, it seems reasonable to conceive of the process set up by light in the retina as reversible, and such that after light, an absence of light will act, as a stimulus to the opposite motion to that generated by the light. Such a conception is by no means absurd, since it is possible to produce a photographic film which shall be insensitive, i.e., remain in equilibrium, under light of a certain intensity, while it undergoes a change when the light is either raised or lowered in intensity from this level. For example, metallic silver in a solution of copper bromide tends to take the bromine from the copper and make silver bromide. On the other hand, the action of light is to drive the bromine off from the silver and leave this in the metallic state. With a certain intensity of light, equilibrium is established between the tendency of the bromine to move to and away from the silver; but if now the light is increased, the equilibrium is disturbed and more bromine leaves the silver, whereas if the light is diminished, the equilibrium is again disturbed and more bromine passes from the copper to the silver. Electric currents are liberated by each of these opposed movements of the bromine ions.<sup>1</sup>

Something like this represents the minimum requirement for a light receiving organ—some substance or mixture of substances in which light sets up motion in one direction, while the inner tendencies of the mixture give rise to a movement in the opposite direction on the cessation of the light. Biologically, it seems reasonable to suppose that the retina has undergone an evolution such that, in its most primitive state, it provided for only one pair of opposed motions. Its photochemical substance must have been similarly though not equally sensitive to light of quite a range of wave-length, corresponding somewhat to the limits of the visible spectrum. This would then be a one-dimensional sense, providing sensations of light and dark in several degrees. The rod sense seems to remain still at this stage of evolution. It seems to have only one reaction to light, irrespective of the wave-length, and one opposed reaction to the cessation of light. The outer zone of the retina, mostly unprovided as it is with cones, remains essentially in this stage of evolution.

The intermediate zone of the retina apparently represents a second stage in the evolution of the visual sense; and the same may reasonably be conjectured regarding red-green blind individuals, since their eyes show no signs of any pathological condition. Color-blindness is not a disease, but is an

innate condition, and may represent something like arrested development or a remaining of the retina at the same earlier stage of evolution as is found always in the intermediate zone. The characteristic of this dichromatic vision is that, in addition to being sensitive to light and dark, it is also differentially sensitive to light of long and of short wave-length. It reacts to long waves by giving rise to the sensation of yellow, and to short rays by giving rise to the sensation of blue. It is probable that the retina, in this stage of development, contains, in addition to the substance which gives opposite motions to light and dark, some other substance or mixture or condition in which a motion in one direction is generated by the long waves and the opposed motion by the short waves. Photochemistry can afford analogies for such a condition. The motion generated by the long waves is not generated with equal ease by all of them, but most readily, it is probable, by waves having a length of about 570, and less and less by waves differing more and more from this length on either side. In other words, the photochemical substance in question is attuned to waves of one length, but responds also to waves not differing too much from this optimum. Similarly, the opposite motion in this substance is best generated by light of about 470, but in a less degree by other waves shorter than about 500. Accordingly, if one excites a dichromatic eye by light from different regions of the spectrum, beginning with the red end, he shall obtain, first, a very dull yellow, then more and more yellow till the maximum is passed, then less and less yellow till the neutral point at about 500 is reached, then a faint blue increasing to a maximum and decreasing again towards the violet end.

But along with this yellow-blue sense, dichromatic vision possesses also the light-dark sense, which responds to all rays within the visible spectrum by a sensation of light, having also a maximum not far from the maximum of the yellow effect, and shading off towards both ends of the spectrum. The total effect on the dichromatic eye from stimulation with any wave-length will therefore be a compound of the light-dark effect with the yellow-blue effect. At the neutral or boundary point of the yellow-blue reaction, the yellow-blue process being in equilibrium, only the light effect results. Again if yellow and blue rays act together, they neutralize each other so far as concerns the yellow-blue process, and leave only the effect of light of a certain brightness. Or, if any combination of long and short waves is so proportioned that the yellow tendency balances the blue tendency, only the light effect remains. If the long waves overbalance the short in any mixture, the effect is yellowish; if the short waves preponderate,

\* Reprinted from the Transactions of the Illuminating Engineering Society.

<sup>1</sup> See Liesegang, "Schwarz als Empfindung," *Zeitschr. f. Sinnesphysiologie*, 1910, 45, 69-70.

the effect is bluish. The saturation of any yellow or blue depends on the relation between the light-dark and the yellow or blue effects, and is greater in proportion as the light is homogeneous and in proportion as it is concentrated about one of the two wave-lengths to which the yellow and blue processes are most responsive. Saturation is, therefore, from the point of view of retinal action, an incidental affair, and not worthy to be regarded as a dimension or independent variable. Yet dichromatic vision is, physiologically as well as psychologically, two-dimensional, the two independent variables being the light-dark process and the yellow-blue process.

Dichromatic vision is simpler and better understood than normal or polychromatic vision. It is natural to suppose that the latter is equal to the former plus some additional process, i. e., that, in the course of evolution, some new photochemical substance or mixture has arisen which is differently sensitized from either the light-dark substance or the yellow-blue substance. Theories differ widely as to the nature of the addition which must be made to dichromatic vision to produce polychromatic vision—or in other words, as to the nature of the subtraction which must be made from the normal eye to reduce it to the color blind condition. The following consideration, however, seems to be important in this connection. Since yellow and blue lights are complementary both to the normal and to the color blind eye, and since, in general, the same pairs of wave-lengths are complementary to both sorts of eyes, it follows that what is added to dichromatic to make polychromatic vision must itself partake of the nature of a complementary, or must consist of two opposed processes of the same general nature as the yellow-blue pair.

Otherwise, two colors which are complementary to the color-blind eye would not be so to the normal eye. Or, to put it otherwise, no single color added to a complementary pair like yellow and blue would give rise to the color circle, but only to half of the colors in it; and no single color added to yellow and blue would give white, since yellow and blue by themselves combine to give white, and the third color would be left over and give its tinge to the mixture. What is added must be of such a character that the yellow-blue mixture plus the new addition shall give the same effect as the yellow-blue mixture alone, namely, white light, since all the

colors mixed together give white. It is probable, accordingly, that the new development which gives rise to polychromatic vision is polarized as the light-dark and yellow-blue processes are polarized. In other words, one should surmise that some new photochemical substance has arisen in the central region of the fully developed retina—some substance admitting of two opposite motions, and so attuned as to give one of these motions under the action of a certain wave-length, and the opposite motion under the operation of some other wave-length; and the colors corresponding to these wave-lengths should be complementary.

The problem would then be to ascertain the wave-length to which each of these opposed reactions is most closely attuned. There are indications, but not conclusive ones, that one of these wave-lengths lies in the neighborhood of 500, namely, in the green or bluish green. But, if so, no one wave-length can be assigned as the optimum for the opposed or complementary reaction, since the green has no complementary within the spectrum. The purplish red, complementary to the green, lies in the non-spectral portion of the color circle, and is produced only by the combination of long and short wave-lengths. It would seem, accordingly, that the red process is attuned to no one single wave-length, but to a certain mixture of long and short waves.

This is a condition of affairs that tempts one to speculation, especially in view of the fact that the longest waves in the visible spectrum are nearly but not quite twice the length of the shortest. The visible spectrum has, in fact, often been likened to a slightly incomplete octave. One is thus reminded of the overtones in sound, and is led to suspect that a photochemical substance attuned to waves at one end of the spectrum would also be sensitive to waves of nearly twice the vibration rate at the other end. It might thus be really the fact that, under the conditions of absorption obtaining in the media of the eyeball, etc., no one ray of light would so effectively excite the red process as a mixture of long and short waves. Besides, to obtain the real effect in its purity, one would need to choose a stimulus which should give a balanced effect on the yellow-blue substance, as otherwise the red would be tinged with a proportion of yellow or of blue. Now, as the yellow process is excited by all rays up to the red end, and the blue process by all rays down to the violet end, the pure

red effect could be got neither from the long waves nor from the short waves alone, but only by neutralizing the yellow effect of the long rays by the blue effect of the short. However, as these considerations are both complicated and speculative, it is wise to admit that the probable physiology of polychromatic vision is still undecided. Enough has certainly been said to justify the thesis that the correspondence between color tone and wave-length is far from presenting that simple character which would be suggested by the rudimentary statement that color depends on the wave-length.

The similar statement that brightness depends on the energy of the physical stimulus is also true only with very serious qualifications. To mention first one or two minor points, brightness depends on the spatial extent of the stimulus and on its duration. Either extent or duration can to a certain degree take the place of intensity of light. A very small surface intensely illuminated may appear less bright than a larger surface under somewhat weaker illumination. A weaker light acting on the eye for a twentieth of a second may appear brighter than a stronger light acting for a hundredth of a second. A light must act for a certain time in order to develop the full brightness to which it can give rise. This time for which it must act is called its "action time," and is, to be sure, very short, ranging from one-fifth of a second when the light is so weak as to be barely perceptible down to a thirtieth when the light is very intense.<sup>1</sup>

The apparent intensity of a light which acts for less than its action time is proportional to the time for which it acts; and this rule applies to intermittent light such as that reflected from a color wheel or such as that of an arc in an alternating current. Here one has, physically, light for a short time followed by darkness for a short time, the two alternating rapidly. If the light lasts for half of the total time, the apparent intensity is half of what it would be were the light physically continuous; and, in general, the apparent intensity of the light is the same fraction of its full possible brightness that the phase of light is of the whole period. This relation between brightness and duration is familiar under the name of Talbot's law.

(To be continued.)

<sup>1</sup> McDougall, *British Journal of Psychology*, 1904, 1, 151.

## New Method of Testing Rails\*

### A Simple Impact Trial

In a series of articles recently contributed to *Le Génie Civil*, Monsieur C. Fremont describes in some detail numerous experiments made to ascertain the characteristics of the types of steel which are liable to produce rail breakages, and develops a proposal for a new and simple method of testing rails, which, we understand, is now being investigated by the French railway companies, and already excellent results are being obtained. In a communication published in the "Bulletin de la Société d'Encouragement pour l'Industrie Nationale" on "Résistance des Matériaux,"<sup>1</sup> Fremont pointed out, and, it can be added, proved that mild steel of good quality which had been exposed to a particular detrimental treatment could pass satisfactorily the usual tensile tests in respect of strength and ductility, but was, notwithstanding, so brittle or fragile that it would break under the effect of a single blow.

In order to discover whether a sample of mild steel has this dangerous characteristic, he devised the well-known one-blow method of impact testing with small specimens (a method which has led to much controversy), and he employed both plain and nicked specimens. In making the rail tests under consideration, however, he only used plain specimens, that is to say, they were not nicked, because he found that with steel suitable for rails nicked specimens always gave a low impact figure, and it is therefore impossible to discriminate between brittle and non-brittle qualities, whereas when plain specimens are used the difference in the impact figure is very marked. The one-blow impact test is so well known that we need not refer to it any further, except to state that Fremont's standard specimens are 8 millimeters deep, 10 millimeters broad, and 30 millimeters long, and for test are placed on knife edges 21 millimeters apart, and are tested by impact bending by one blow from a tup 10 kilograms in weight and falling 4 meters, so that the striking energy is 40 kilogramme-meters, or 290 foot-pounds. Tough steel merely bends and shows little or no sign of crack; brittle specimens do not bend but crack right

across. A test piece is deemed to be dangerously brittle if the energy absorbed in breaking it is only 20 kilogramme-meters, or less, say 145 foot-pounds.

In applying this method of research the rail sections under investigation were cut up into 41 test pieces, as indicated in Fig. 1; and broadly, the result of tests with a large number of rails of all descriptions, shows that in brittle rails the test pieces in the interior of the head and those in the web—that is, specimens 6 to 18 and 20 to 26 in Fig. 1—have an impact figure less than 20 kilogramme-meters; and the remaining test pieces, except in very inferior rails, give a good impact figure. It is obvious that the cost and delay of cutting up a rail section into so many small test pieces would be impracticable; and therefore Fremont has

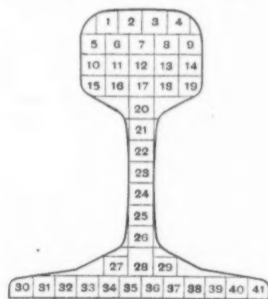


Fig. 1.—System of numbering impact pieces.

devised a simple impact test based on these results, and which can be carried out with a short length of rail of the full section after removing at the center of the length the top portion of the head, namely, test pieces 1 to 4. (A photograph of a length of rail so prepared is reproduced in Fig. 19.) He has also designed an apparatus for carrying out this test, of which he gives particulars, and to which we will refer more fully later.

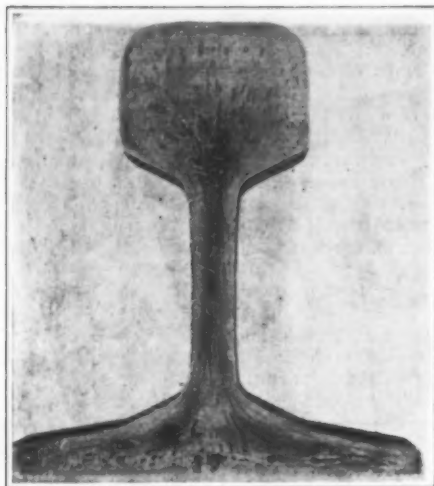
The importance of the subject can be realized from the fact that in recent years rail breakages in France

have been as frequent as 1 in 2,000 of the rails in service; in Germany it is as much as 1 in 1,150 rails. In the United States of America breakages had become so frequent that the matter amounted to a scandal, and the trouble was ascribed, in an article published by the Association of the International Railway Congress in December, 1907, to the action of a ring of steel makers. It is stated in this article that "there is no individual, or combination of individuals, which knows better how to make good rails than does the United States Steel Corporation with its splendid army of experts. Nevertheless, it knowingly makes rails which break and kill people. The top of ingots are not cropped off below the point where high phosphorus and impurities are found." This article contains information of much importance in this connection, and there are many letters from engineers and managers pointing out the great increase in rail breakages, and stating that inferior rails are the cause. There are also many photographs showing brittle rails. To this accusation the steel makers replied that the increased breakages were due to the increased traffic, and suggested the adoption of a heavier rail, namely, as much as 150 pounds per yard. Fremont states that in France similar occurrences have been noted, and that whereas in the case of derailment, the rails have been bent and twisted like a corkscrew, without breaking, yet rails that have broken in service never show any deformation at the fracture.

Fremont contends that the etching test sometimes prescribed is not satisfactory, and, as example, he gives reproductions of two etched macrograph sections, viz., Figs. 2 and 3, of which, although the latter appears worse than the former, the rail only broke after some service, whereas the other broke while being laid. It will be observed, however, that in Fig. 3 the outside metal appears satisfactory, and it is no doubt owing to its resistance that the rail withstood some service. On the other hand, macrograph sections of other rails showed no stains and yet were proved to be fragile by the new method of testing about to be described.

Fremont began his inquiries into the resistance of

\*The Engineer.  
Sept. 1901, p. 365.

Fig. 2.—Rail  $T_1$ .Fig. 3.—Rail  $T_2$ .Fig. 4.—Rail  $T_3$ .

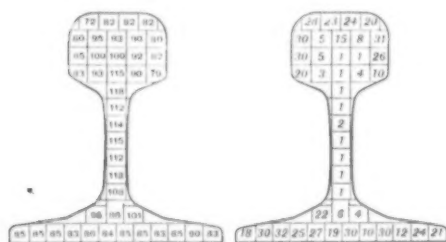
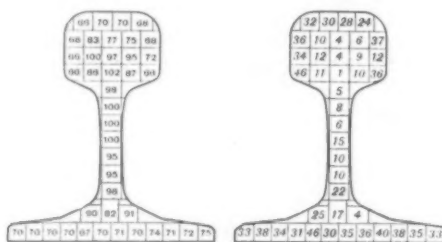
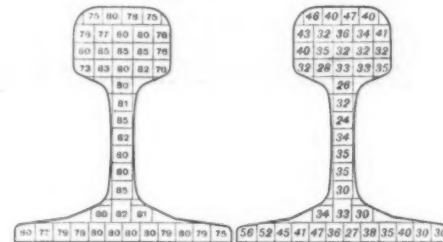
rails in 1897 and made a communication on the subject to the International Congress on the Methods of Testing Materials of Construction in 1900, and again in 1903 to the Académie des Sciences. No practical result followed, however, probably because the number of rail breakages was then inconsiderable. He thinks that to-day the situation has changed, and that the numerous failures of rails, and the disasters to which some of them have led, will induce the authorities seriously to consider the matter.

Subsequently Fremont took three rails, one (marked  $T_1$ ) which was so brittle that it broke while laying, another (marked  $T_2$ ) which broke after a short period of service, and the third (marked  $T_3$ ) a normal rail of average good quality. Macrograph sections were taken of each rail (Figs. 2, 3 and 4) and 41 impact test pieces were prepared in accordance with the scheme

was low. The test pieces were reassembled in their proper positions in the rail section and then photographed; the result is given in Figs. 8 and 9 for rails  $T_1$  and  $T_2$ , and is most striking, and no doubt can be left as to the cause of the brittleness of rail  $T_2$ .

Fremont discriminates between two kinds of brittleness. In the first case, the material is originally tough and the brittleness does not become apparent until after several years of use, due, it would appear, to the hardening effect of the pressure caused by the wheels, producing minute cracks at right angles to the length of the rail. These cracks, being external, are easily detected, and no serious danger should result from them; they are probably due to the material of the rail being originally too soft. Fremont gives examples of these rails—see Figs. 10 and 11. In the second case, the material of which the rail is made is initially

a typical rail of this nature in which low impact figures are obtained at the center of the head and in the web, and good impact figures at the foot. The ordinary tup test in France generally prescribes that the foot of the rail shall be underneath; that is to say, is put into tension on receiving the blow. It is obvious that a rail of the nature of that shown in Fig. 3 will, under these circumstances, pass the test satisfactorily owing to the tough material in the foot and at the outside portion of the head. If, however, a certain portion of the depth of the head be removed, the brittle portion is exposed, and if, further, in making the top test this brittle portion is placed underneath so as to be put into tension on receiving the blow—that is to say, if the position of the rail were reversed as compared with the present generally prescribed test in France and elsewhere—it would be fractured with one,

Fig. 5.—Rail  $T_1$ .Fig. 6.—Rail  $T_2$ .Fig. 7.—Rail  $T_3$ .

given (Fig. 1) and after the impact test, one end of each specimen was sheared, from which the ultimate tensile strength was deduced from the empirical formula:

$$T = \frac{C - 7.5}{0.34} \text{ kilogrammes per square millimeter,}$$

which Fremont had obtained from previous experiments. The results of these tests are given in Figs. 5, 6, and 7, and it will be noticed, as already mentioned, that the specimens in the center of the head and in the web of brittle rails,  $T_1$  and  $T_2$ , have low impact figures. The tensile strength was satisfactory in every case, but was somewhat high when the impact figure

was low, and, according to the amount of this brittle material in the rail section, the rail will break, either after some service, or even during transport or laying.

For example, in a rail like  $T_2$ , vibration and shock will produce internal cracks which take their origin in the area of segregation and gradually extend from one grain of impurity to another. Fremont gives some interesting micrograph sections of such cracks as shown in Figs. 12 and 13. Such internal cracks are extremely dangerous, as they cannot be seen, and therefore no warning is given; and it may be said that the author's investigations and the new test he proposes are principally addressed to detecting rails subject to this defect. As already mentioned,  $T_2$ , Fig. 3, is

or at most two, blows if it were brittle internally.

This modification in the usual tup test constitutes Fremont's proposed new test, and it has the advantage that it can be carried out with short pieces of rail, say, 18 inches to 19 inches long.

A series of trials was made to ascertain how much of the head of the rail should be removed, and it was found that the depth of the cut should not be less than of the fly-wheel type, and its construction will be clear two lengths of rail—as shown in Fig. 14—and cut out a "circular nick" as indicated in the figure.

The machine preferred for making the impact test is of the fly-wheel type, and its construction will be clear from Fig. 15.

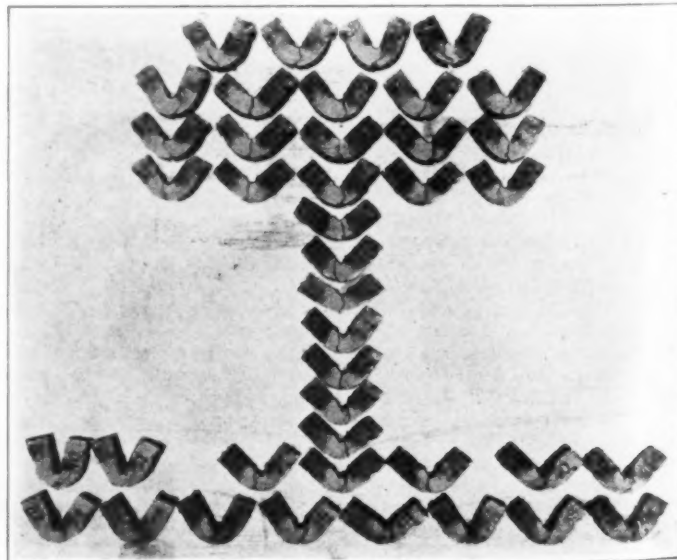
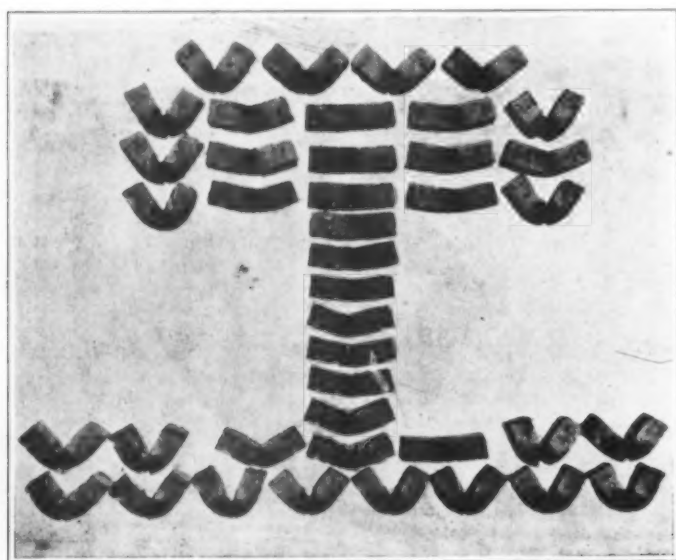
Figs. 8 and 9.—Test Specimens From Rails  $T_1$  and  $T_2$ , Arranged in Order.



Fig. 10.—Rail Showing External Cracks.

gramme-meters (10,800 foot-pounds) approximately. Rails from various sources were tried by this new method, and particulars of several are given. In each case the macrograph section was obtained; impact tests on small section were made in the manner previously referred to, and the results were compared with the new method. Full particulars, together with reproductions of the macrographs, etc., of eighteen of these rails are given, out of which Figs. 16 to 22 have been picked out as typical examples.

The first four figures refer to brittle rails, and the last three to satisfactory rails of a tough description. In each figure the top view shows the short length of rail either fractured or bent as a result of the test. The next is a reproduction of the macrograph sec-

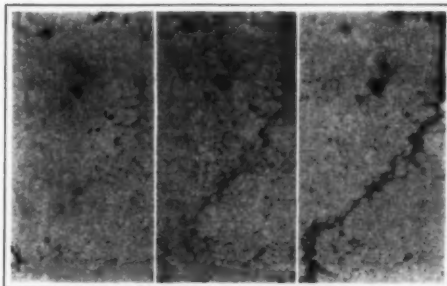
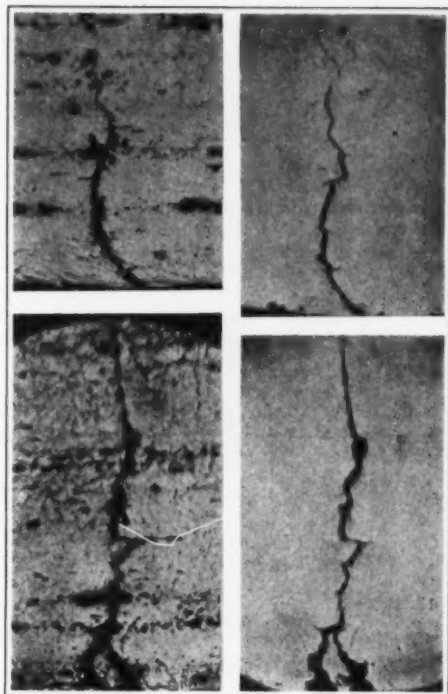


Fig. 12.—Internal Cracks Magnified.



Polished. Etched.  
Fig. 11.—External Cracks Magnified.

The piece of the rail is placed horizontally on the platform (4), supported by springs (5), which can be released by means of a trigger (7), and so shoot up the platform with the rail on it at any moment desired, so as to be hit by the projection (2) on the fly-wheel. The energy in the fly-wheel is 1,500 kilo-

ton, and the remainder of the figure gives the impact figure for each of the small impact test pieces numbered 1 to 21 cut out of the rail section in accordance with the numbering of the specimens indicated in Fig. 1. The dotted line shows the 20-kilogramme meter limit, and it will be noticed that in the case of the brittle

rails, i. e., those that broke without deformation at the first blow, many, and in one case, all the impact figures are below the limit.

An examination of these figures shows that there is

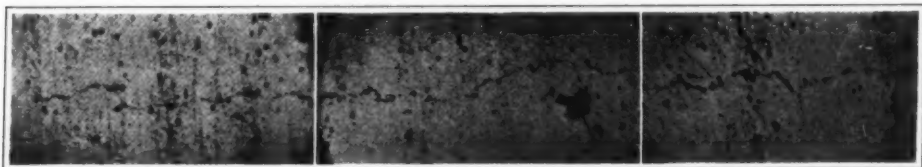


Fig. 13.—Internal Cracks Magnified.

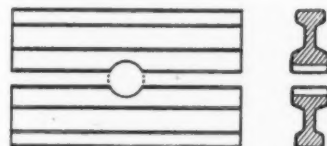


Fig. 14.—“Circular Nick” in Clamped Rails.



Fig. 16.—Brittle Rail Showing Considerable Stain.

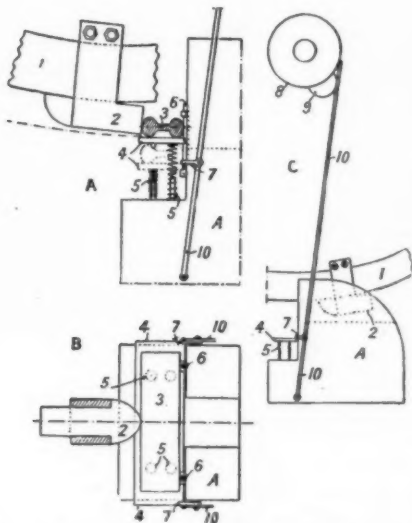


Fig. 15.—Impact Testing Machine.



Fig. 17.—Brittle Rail Showing Very Little Stain.

no co-ordination between the macrograph section and the brittleness or toughness of the rails. Thus in Fig. 16 the macrograph stain is considerable, and substantially the same as that of Fig. 21, yet the first rail was brittle, whereas the second was tough. Again, in Figs. 18 and 20 the stains are moderate, and the first rail was brittle, and the second tough. Fig. 22 shows very little stain, and the rail was tough, but about the same amount of stain is shown in Figs. 17 and 19, and yet both these rails were brittle. It will be seen that if the macrograph test were alone relied upon, then rail 21, and possibly 20, would have been condemned, whereas they ought to have been passed, and rails 17 and 19 would have been passed, whereas they ought to have been condemned.

So far as the tests referred to are concerned, the new method appears to discriminate satisfactorily between sound and unsound rails. To establish this method as a standard method will require undoubtedly further independent research, but the work already done by Fremont is amply sufficient to show that present methods are—to put it mildly—not always reliable and that the new method merits further close study with a view to its adoption.



Fig. 18.—Brittle Rail Showing Moderate Stain.



Fig. 19.—Brittle Rail Showing Very Little Stain.



Fig. 20.—Tough Rail Showing Moderate Stain.



Fig. 21.—Tough Rail Showing Considerable Stain.



Fig. 22.—Tough Rail Showing Very Little Stain.

# The Power Required to Cut Steel\*

## The Influence of Chemical Composition and Previous History

By P. V. Vernon

MOST published data in connection with metal-cutting experiments have related chiefly to the behavior of the tool steel, the material operated on having been maintained, as far as possible, constant in its properties, the idea in most cases having been to obtain knowledge of the cutting qualities of the tool. So far as is known to the writer, there is a dearth of accurate information dealing with the effect of variations in the material being cut on the power required to cut it.

In connection with hitherto published tests, the particulars of the materials being cut have, in the writer's opinion, been insufficient, e.g., in some cases the analysis and physical tests have been given, but not on a progressive series of samples all being cut under the same conditions, and it is therefore felt that there is some need for data dealing with the relation between the quality of the steel cut and the power required to cut it, meaning by quality something more than analysis and strength.

Without such data, it might be reasoned that because one steel contains more carbon or more manganese than another, or because it is stronger it must therefore be more difficult to cut, and must consume more power in being cut. The figures that follow will show that any reasoning based on such assumptions will, in many cases, lead to totally wrong conclusions.

In cases where particulars of cutting tests have been given, the analysis only of the steel has been recorded,

brated by the makers for all loads and speeds, so that the actual brake horse-power at the pulley could be read off a chart from the speed and ammeter readings. The amperes required to run the lathe light were, however, first deducted so as to enable all sources of frictional loss to be as far as possible eliminated. The lathe was actually run at the same speed and feed for all the cuts taken the idea at the root of the experiments being that the steel itself and the power required to cut it should be the only variables.

Six kinds of steel in all were tested, each being tried under different conditions of temper, fifteen actual tests being made. The steel was dealt with in the rolled bar, all bars being 2 inches in diameter. Steels below 0.210 carbon were tested in two conditions, viz., as received from the makers, and after annealing. Steels above 0.210 carbon were tested in three conditions: (1) as received from the makers, (2) after annealing, and (3) heat treated. The actual conditions of annealing and heat treating were the same as would be used by Alfred Herbert, Limited, when preparing the steel for manufacture into parts of their various machines. The fifteen bars on which the cuts were taken were each analyzed, tested on the tensile machine, and also for hardness by the Brinell ball test.

The speed at which the tests were made was naturally not the maximum that could be taken, as it had to be

$$H.P. \times 33,000$$

$$P = \frac{S \times a \times 2240}{\dots}$$

where  $P$  = Pressure on tool in tons per square inch.

$HP$  = Net horse-power.

$S$  = Cutting speed in feet on mean diameter of work.

$a$  = Area of cut (fraction of a square inch), or in the present example  $P = HP \times 20,625$  tons per square inch.

The pressures are only conventional, being based on the usual assumption that the whole of the pressure bears uniformly on an area equal to the sectional area of the cut, whereas, as a matter of fact, the chip bears with a far from uniform pressure and rubs on a considerably larger area on the tool. The figures are, however, along the lines of previous published results by Nicolson and others, and will serve for comparison.

The actual pressures are also rather less than those given, because the horse-power figures include the excess of friction when running under load over that when running light, but the differences will be very small, as all the bearings were ball bearings.

A study of the physical tests will show the effect of the heat treatment, and on this point some remarks may be interesting. Samples Nos. 1 and 2 consist of bright drawn steel of English make. It will be noted that in sample No. 1, as received from the makers, the elastic stress and the maximum stress are almost identical, this being due probably to the effect of the drawing, which, however, must have permeated the entire bar, as the test pieces were cut from the center of the bar. Test No. 2 shows that the annealing has restored the steel to a more normal condition.

Nos. 3 and 4 were bright drawn steel bars of American make, and the same characteristics as in the case of Nos. 1 and 2 can be seen, although to a less degree.

Samples Nos. 5 and 6 are very little affected by annealing, the steel in question being a very soft steel used for unimportant details.

Samples Nos. 7, 8, and 9 represent a steel used for screws, handles, and other unimportant parts. It will be noted that both annealing and heat treatments have increased both the tensile strength and the elastic stress.

Samples Nos. 10, 11, and 12 represent a steel used for transmission shafts and important parts of machine tools. It will be noted that the effect of heat treatment is to increase both the maximum stress and the elastic stress. In both these instances the elongation is slightly reduced by heat treatment, but not sufficiently to be of importance.

Samples Nos. 13, 14, and 15 represent a high carbon spindle steel, which is heat treated for the purpose of normalizing it and of enabling it to be more easily machined, and in this case both the annealing and heat treatment have the effect of somewhat reducing both the maximum and elastic stresses, and naturally of increasing the elongation.

Dealing with the question of hardness, it will be seen that in the cases of tests 1 to 6 the effect of annealing has been to soften the steel, the smaller Brinell numbers corresponding to the softer conditions.

Tests 7 to 12 show that both annealing and heat treatments harden the steel, whereas tests 13, 14 and 15 show, as would be expected from the purpose of the heat treatment, that the hardness is reduced.

Coming now to the net horse-power required for the various cuts, it is curiously difficult to find anything in the nature of a law except in a very broad sense, but there are one or two striking facts which stand out prominently. The first of these is that in every case annealed steel require more power to cut it than unannealed, i.e., as received from the makers. That is to say, that although in some cases annealing has increased the tensile strength, and in other cases it has decreased it, in all cases it has increased the power required to cut the steel. This fact was quite unanticipated before the tests. Secondly, it may be said in a very broad way that the power required increases with the carbon content, but this cannot by any means be taken as a rigid law, as may be seen by the following exceptions, of which there are many.

For example, in No. 4 test, steel having .14 per cent of carbon, consumed 3 horse-power, whereas in No. 1, steel with 50 per cent more carbon only required 2.375 horse-power. In No. 8 test, steel with .22 per cent carbon required 6 horse-power, whereas in No. 15 test, steel with as much as 0.72 carbon only required 5½ horse-power.

Compare also Nos. 2 and 9 tests, in which the carbon contents are identical and the tensile strengths not very different, yet the horse-powers required are 3 and 6½ respectively.

It will thus be seen that neither carbon content nor tensile strength give definite basis for a law, and the

Power Required to Cut Steel.

Kind of steel.	Test No.	Condition.	Analysis.					Physical tests.					Net H.P.	Mean pressure on tool. Tons per sq. in.
			Carbon. Per cent.	Silicon. Per cent.	Manganese. Per cent.	Sulphur. Per cent.	Phosphorus. Per cent.	Max. stress. Tons per sq. in.	Elastic stress. Tons per sq. in.	Elongation on 4.5in. Per cent.	Reduction of area. Per cent.	Hardness. Brinell number.		
English bright drawn ...	1	As received	.21	.075	.670	.038	.033	31.32	31.00	20.90	61.52	158	2.375	48.98
	2	Annealed	.20	.075	.670	.038	.033	26.80	16.40	32.44	68.04	125	3.000	61.87
American bright drawn	3	As received	.14	.038	.580	.006	.092	33.52	29.20	17.83	55.84	166	2.375	48.98
	4	Annealed	.14	.038	.590	.006	.092	30.24	22.00	23.33	62.17	148	3.000	61.87
Siemens basic ...	5	As received	.08	.005	.250	.030	.030	24.20	15.40	27.55	56.32	120	4.000	82.50
	6	Annealed	.08	.005	.240	.032	.030	23.68	16.00	33.34	69.04	118	5.000	103.12
Siemens open hearth basic	7	As received	.22	.017	.590	.041	.053	23.00	15.60	30.44	60.40	136	4.000	82.50
	8	Annealed	.22	.017	.540	.044	.053	32.00	18.00	27.77	51.73	149	6.000	123.75
	9	Heat treated	.20	.017	.532	.041	.034	32.00	21.00	26.44	64.76	163	6.500	134.06
Siemens-Martin acid ...	10	As received	.36	.113	.640	.022	.040	34.28	22.00	24.44	60.64	174	7.000	144.37
	11	Annealed	.48	.056	.542	.019	.022	38.00	25.20	24.00	60.40	182	7.500	154.68
	12	Heat treated	.48	.060	.552	.019	.021	41.24	29.00	18.88	62.84	194	6.750	139.22
Siemens-Martin acid ...	13	As received	.72	.150	.840	.025	.039	52.88	33.00	14.44	21.48	240	6.000	123.75
	14	Annealed	.72	.140	.839	.025	.039	41.72	23.60	22.90	53.92	193	6.700	138.18
	15	Heat treated	.72	.140	.830	.028	.039	46.20	26.80	19.55	37.80	205	5.500	113.43

All fractures were silky fibrous, except Nos. 13 and 14, which were fibrous in center and crystalline outside.  
Cutting test consisted of reducing the bar from 2 inches to 1 inch at 204 turns per minute—106.8 feet per minute maximum, or 80 feet per minute on mean diameter of cut.  
Feed fifty-six cuts per inch.  
Metal removed 8.58 cubic inches per minute.  
Same tool used throughout and sharpened for each cut.

and in other cases the strength only. With such incomplete particulars it is almost obvious that no conclusions of any value can be drawn, as, for example, we know that any steel reasonably high in carbon may exist in all kinds of conditions from the soft state to the dead hard, each of these conditions considerably affecting the problem of cutting it.

The experiments described below were undertaken in order to find out, if possible, the effect of the different factors producing "quality" in steel of the kind used for building machinery, on the power required to cut it in a lathe. Earlier experiments made in connection with tests of tool steel had already indicated that the amount of carbon in the steel gave little indication as to the power required to cut it. Some high carbon steels required less power to cut them than other steels of lower carbon, and it was therefore thought worth while to make a series of tests with steels of different compositions and strengths, and with different heat treatments, in order to arrive somewhere near to the actual facts.

Although an orderly mind may regret that the results do not reveal anything in the nature of a scientific law, it is nevertheless thought that their publication may stimulate further investigation, and may remove certain misapprehensions from the minds of machine tool users. After all, the absence of definite mathematical relations does not necessarily render experimental results valueless.

The tests were made in the experimental workshop of Alfred Herbert, Limited, the machine used being a hexagon turret lathe, having a single pulley head, fitted with ball bearings throughout. The lathe was driven by a variable speed motor which was carefully cali-

slow enough to cut the steel which offered the greatest resistance to cutting, so that the output was, of course, only moderate, the object being to show a ratio rather than a gross quantity, that is to say, to show the relation between the various items entering into the quality of the steel and the power required to cut it.

The cutting tool was a side cutting tool made of high-speed steel 1 inch deep by ¾ inch wide, having top rake of 35 degrees and clearance angle of 7 degrees. The same cutter was used for all the tests, and was sharpened after each cut. The test consisted in turning down the series of 2 inch bars to 1 inch diameter at 204 revolutions per minute with a feed of fifty-six cuts per inch, this giving a cutting speed of 106.8 feet per minute on the periphery and 80 feet per minute on the mean diameter of the cut. The cutter was carried and the work was supported by the standard roller steady turner belonging to the lathe, careful records being kept of the power consumed.

The table gives the whole of the results of the tests. The bars were numbered 1 to 15, and where two numbers are bracketed together the bars were nominally identical, the difference in analysis shown in the table being due to the unavoidable small variations in composition of the bars, and those in the physical and cutting tests being due to the differences in the heat treatment given to the bars before test. An exception occurs in the case of bar No. 10, in which case obviously a kind of steel different from Nos. 11 and 12 was used, the bar evidently having accidentally crept into the maker's consignment. In the last column in the table, the mean pressures of the cut per square inch on the tool are given, having been calculated from the following formula:

\* The Engineer.

same can be said in general for all the other columns in table. It will have been observed, for example, that some of the annealed steels are softer than in the "as received" condition, whereas others are harder, yet in all cases the annealing puts up the power. It is perhaps conceivable that some complicated formula might be evolved by which the cutting power could be determined from the analysis, physical tests and heat treatment; but with existing knowledge the only solution of the problem

seems to be actually to cut the steel and to measure the power.

The tests may be criticised in that they do not carry our knowledge very much further; but the writer's excuse for them is that they may enable false deductions to be avoided in the future. The experiments, in his opinion, have made clear that no figures as to the cutting power of machine tools are of much value unless very much fuller particulars are given than is usual of the

composition and properties of the materials being cut.

The feeling left in the writer's mind after having carried out these tests is that something further is required in the nature of a standard test before we know all about the physical properties of steel under the action of a cutting tool, and that permanent records of the power required to cut standard test pieces with a standard tool at a standard speed and fed with a standard machine might have some uses.

## Developing a Small Water Power Plant\*

### Electric Power for the Farm and Country House

WHILE it may be a pleasing exercise of the imagination to picture the country as dotted over with tiny hydro-electric plants, and to think of the farmhouses as blazing forth with all the brilliance of innumerable electric lights, yet to the average farmer the contemplation can not seem to be related to the practical workings of every day life.

And the reason for this is not that the water power is not there awaiting development. Neither is it because the farmer can not afford the necessary expense of effecting this development. On the contrary, there are hundreds of farms in the State, probably thousands, where power enough could be developed to do the work year in and year out of two hired men, and at an expense less than their wages, for a single year.

The reason is rather that the farmers generally feel that they lack the knowledge necessary to buy, to install and to operate the requisite equipment.

If this were a necessary bar to the development of the water powers, there would be little point to the publication of this bulletin. The manufacture of hydraulic and of electrical machinery has reached such a degree of perfection that self-oiling machines can be had, which, when properly installed, will operate for long periods at a time with practically no attention. The first cost of such plants as are here contemplated is almost the only cost, and the life time of the equipment should be nearly or quite a generation. This last statement is not intended to cover electric lamps of course; but the average life of the recently perfected tungsten lamps is about 1,000 hours of burning, and the expense of the renewal of lamps would be but a fraction of the present cost of kerosene in the average farmhouse.

The prime requisites for a small water power are, first, a stream of water of an appreciable volume, and second, a water fall, rapid, or gradient of appreciable amount. In round numbers a stream having a flow of one cubic foot per second will generate one theoretical horse-power for every ten feet of fall it has. Thus, a stream flowing four cubic feet a second, and having a fall of 30 feet, could generate 12 theoretical horse-power. The fall may be in the nature of a water fall, with more or less nearly vertical drop, or a rapid with a fall of one foot in ten to one foot in two, or of only a few score feet per mile. In some cases the fall may be obtained by building an impounding dam at the foot or lower end of the fall or rapid. In other cases the fall is utilized by building a dam at the upper end and carrying the water by pipe or canal to a point below the foot of the fall where the power plant is located. In the last case the water may be diverted at the head of the fall or rapid, or at the highest point of the stream on the land in question and carried along the hillside in a canal with just sufficient grade to insure a flow to a suitable point, then turned into penstocks and carried down to the power plant or out onto an overshot wheel; or the water may be carried in a strong, tight pipe following down the grade of the stream to where it is to be used. With some streams only a diverting dam of small cost will be necessary; in other cases it may be necessary to build impounding dams, so that a small amount of water accumulating through the 24 hours will furnish the desired amount of power through a relatively few hours. Those questions all require judgment. The diverting dam has the advantage of small initial cost, but the open canal is liable to freeze in winter. On the other hand, there are many streams which, while yielding an abundance of power through certain months of the year are apt to go nearly dry at times in the summer. For such streams storage dams are necessary if they are to run all of the year. Such dams may be only large enough to store a sufficient supply for the day's use, depending on accumulating enough during the 24 hours to run their motors the few hours that are often necessary; or they may be built large enough to store water during the wet season of the year for use in the dry seasons.

As a rule, it is true that the small streams are more subject to fluctuations than the larger streams or rivers. But in this State the existence of limestone and other

springs is often more important than the size of the stream. Thus on the sandy areas of the Cumberland plateau or edge of the Highland Rim the rainfall, tends to sink into the ground, and the surface streams, which may be of considerable size just after a rain or during a rainy season, may be entirely dry during several months of the year; while other streams in the limestone portions of the State with an equal yearly flow may maintain a fairly uniform flow all of the year. While almost no figures are at hand of the flow of the small streams, as a rule those through whose land the stream flows know from experience about what flow can be counted on for different seasons of the year.

In determining the "run-off" the term "second-foot" is used. It is an abbreviation for cubic foot per second, and is the rate of discharge of water flowing in a stream one foot wide, one foot deep, at the rate of one foot per second. It equals 7.48 United States gallons per second. In making calculations one second-foot falling 8.8 feet equals 1-horse-power, and one and a third horse-power equals one kilowatt. To determine the horse-power on a wheel realizing 80 per cent of its theoretical power, the following formula is used:

$$\frac{\text{Second-feet } \times \text{ fall in feet}}{11} = \text{net horse-power.}$$

To obtain the flow of the stream in second-feet roughly, select some portion that is as straight and uniform as possible, for say 300 feet, then measure the width and depth at six or eight places from which may be obtained an average width and depth. This multiplied together will give the average cross section in square feet. Next drop a float on the water noting the number of seconds it takes to travel the given distance. From this can be calculated the velocity of the water in feet per second. Multiply this by the average cross section in square feet and the product will be the cubic feet per second of flow. As the surface velocity is somewhat greater than the average velocity, the result should be reduced one-fifth. For somewhat larger water powers, as for the supplying of villages, the more accurate methods of using the weir or current meter should be resorted to.

It is decidedly of advantage to know, if possible, the net horse-power obtainable at all seasons of the year through measurements. Suppose that it be found that at a certain point 20-horse-power could be obtained during three months of the year, 12-horse-power during six months, and an average of 3-horse-power during the remaining three months without storage. It is evident that a 3-horse-power plant could run throughout the year and if that power be sufficient for the purpose desired, it would be a matter of economy to put in a plant of that size. Experience has shown, however, that having the power available has led to its being used in ways not contemplated at first. There is also the conservation factor of making the largest possible use of the power available. Under these circumstances it would be wise to consider, if it be not possible to tide over the three dry months, either by reducing the demand on the power at that time, or by increasing the power by water storage, or to supplement the power by the use of storage batteries, or a gasoline engine or both, or in some other way, it may then become possible to install a 12-horse-power plant, which, if not all needed on the farm, could often be used to supply adjoining farms at a fixed meter rate, and thus help to return the original cost. By the use of storage batteries for the storage of electricity made during the hours of small demand it may be possible to maintain a limited service as by the storing of water during hours when the demand does not equal the supply. In the case of a small stream that practically dries up in the summer, more primary motor must be used, such as a gasoline or kerosene engine. In many such cases it will be possible to return to the old practice for some or all of the power required during the dry seasons, or the putting off of the doing of unnecessary things until rains have made the power available again. Streams having only one or two square miles of drainage frequently dry up in the summer. The larger streams of Tennessee should develop from one twentieth to one-fourth cubic feet of water per second for every square mile of area they drain.

There are various ways of developing the power of falling water for practical purposes. For large streams,

with small fall, the hydraulic ram is sometimes used. This is a device by which the fall of a large volume of water is used to raise a small volume of water to a much greater height. The efficiency varies with the fall and other factors. Thus with a 2-foot fall, the smallest that can be effectively used, one thirteenth of the water can be elevated to a height of 20 feet. Under favorable conditions water may be elevated to as much as 120 feet. When so elevated the water may be used either as a water supply, or as a source of power by allowing the elevated water to fall again and utilizing its fall. The old method of utilizing falling water was by water wheels. The undershot, overshot and breast wheels were much used in the early days, being easily manufactured of wood at home. The undershot is used where the fall is very small, the water being gathered into a flume, and the wheel arranged so that the paddles on the lower side of its circuit dip into the rapid current of the flume and the pressure on them turns the wheel. If the fall is several feet, a breast wheel may be installed in which the flume has the form of a quarter of a circle enclosing the paddle for a quarter of its circuit, and in this case, not only the impact of the water, but its weight as well, help to turn the wheel. In the overshot wheel the fall is great enough to be carried out to the top of the wheel, where it flows into buckets or against inclosed paddles, and its weight alone turns the wheel. Another style of wheel of more recent origin makes use of the impact of the water escaping from a nozzle or small orifice under high head against the paddles or vanes of the wheel. This will be an orifice opening from the base of a dam, or it may be the end of a pipe extending down from the source of supply. In later wheels the paddles were replaced with cups into which the impulse of the jet of water is carried, making a wheel revolve. The turbine wheel is a modification of the impulse wheel, in which a series of curved vanes or runners, with an arrangement similar to a screw are so placed in a tube as to receive the impulse of water escaping from that tube, the escape of the water being guided so as to produce the greatest impact against the vanes, and these being solidly connected to a shaft either horizontal or vertical, transmit the revolutions to the machinery.

In mountain water power flour mills, it is often the practice to use a crude impulse wheel, turning on a vertical shaft to the top of which is attached the under millstone. But in most cases, especially those here considered, some other method of transmitting the power will have to be sought. If the work is all to be done at the power site the power may usually be transmitted by belting running on pulleys attached to the water wheel and to the machine to be run. If more than one machine is to be run, or at more than one speed, it will be necessary to use an intermediate shaft with pulleys of different sizes.

When the power is to be used at some distance from the power site it will usually be found that it can best be transmitted by electricity. That means the use of a dynamo at the power plant, wires to carry the current and a motor at the points where the power is to be applied. In this process there are a series of losses which sum up just about one-half of the power available.

Hand in hand with the development along the line here indicated should go an improvement in the living conditions on the farms. Specifically is meant by this the installation of running water in farm houses, general introduction of bathrooms, etc. On many farms where no water can be had a hydraulic ram can be used to pump water for the house.

In connection with the small water powers which are too large for development by individual farmers solely for their own use, some extended state action may be necessary. A law somewhat analogous to the draining law should be framed, providing for the formation of water power districts and making provisions for legalizing the necessary condemnation and assessments for supplying the funds through the use of bonds by the county, and for the refunding of such moneys by the individuals and communities benefited, and for the necessary surveying and engineering control, etc., of such developments as shall be made under the provisions of the law. The passage of such a law would bestow upon Middle and East Tennessee benefits comparable to those conveyed to the western section of the State by the drainage law.

\* Extracted from an article on "The Utilization of Small Water Powers in Tennessee," by John A. Switzer, associate professor of experimental engineering, University of Tennessee, and George H. Ashley, Tennessee State Geologist, in the July issue of the *Resources of Tennessee*. Published by the Tennessee State Geological Survey.

# Cheddar Cheese Making\*

## A Phase of Dairy Industry

By G. C. Sawyers, Cheese Expert

CHEDDAR cheese is the most popular cheese with English-speaking people. Its name is derived from a small village of that name in Somerset, England. In that district this cheese was made over 300 years ago. The system gradually spread to the principal British

by the late Mr. David Wilson about 1892, when at several factories the necessary plant was installed. A small quantity was exported and satisfactory prices obtained, up to \$14 per hundredweight; but it was not persevered with. Last season, again, a small quantity was exported with very encouraging results, over \$15.25 per hundredweight being realized for some makes. The quality was very favorably commented upon by the experts in the trade in England, which shows that the country and climate are thoroughly suitable for the industry. A large expansion in this branch of the dairying industry should therefore occur in the near future.

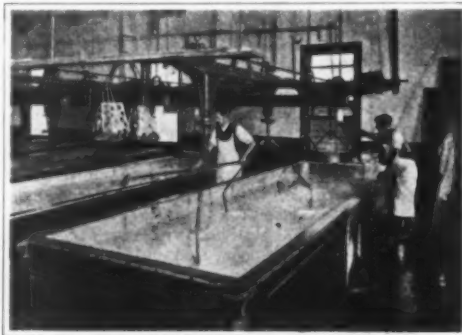
### CHEESE AS AN ARTICLE OF DIET.

Cheese is highly nourishing, and is one of the staple articles of food of the masses in Great Britain, where the imports amount to over \$30,000,000.

Cheddar cheese, when properly made from sound milk of average composition, is of rich quality, perfect solidity, mellow or plastic, and of specially mild and pleasing flavor, reminding one of a pipe hazel nut. It will keep under proper conditions, and with continual improvement, from one to two years; or it may be consumed when three to four months old, and at the latter age is more digestible than most other makes of cheese.

The average analysis of matured cheddar cheese is as follows:

	Per cent.
Water .....	30.32
Fat .....	35.53
Casein .....	28.18
Salt, Ash, etc.....	5.97
	100.00



Heating and Cooking the Curd.

Or roughly, about one-third fat, water, and casein respectively.

Although due, to some extent, to the butter fat which it contains, the peculiar mellow appearance and texture of choice cheddar are more largely the result of the breaking down which the casein or curd undergoes during ripening. The curd is hard and insoluble in water when first made, but by degrees it becomes softer and more soluble; or, to speak more correctly, gives rise, by the processes of fermentation, to products which are soluble in water. If cheese is consumed before this ripening process has developed, it is neither so wholesome nor nutritious as when properly ripened. The proper ripening of the cheese depends principally on the manufacturing process and the subsequent treatment of it while ripening.

### MILK.

Milk is a very complex substance and is a perfect food. It will be sufficient to note its principal contents, which are as follows:

	Per cent.
Water .....	87.00
Fat .....	4.00
Casein .....	3.00
Sugar .....	4.75
Ash .....	.75
Albumin .....	.50
	100.00

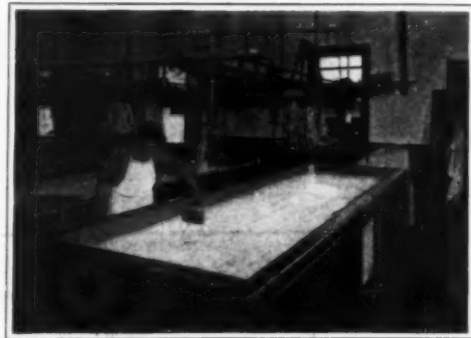
The contents chiefly of value in the manufacture of cheese are the fat, casein, water and a little sugar and mineral matter. Nearly all the sugar and albumin, about half the ash, and a little fat, escape in the whey during the process of manufacture.

Cheese is made by the action of rennet, which is an extract of the stomach of the young calf. It coagulates

the casein and causes it to envelop the contents which are subsequently converted into cheese.

### CHANGES DUE TO BACTERIA.

It is all important that some of the changes to which the solids of milk are subject should be understood.

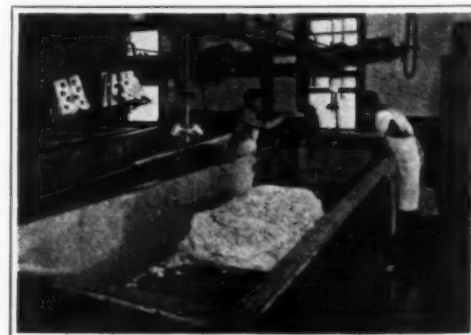


Cutting the Curd.

They are principally due to bacteria. While in the healthy udder, the milk is practically free from bacteria, but as soon as it leaves the udder it becomes inoculated by various kinds that are always present in the atmosphere.

Immediately these bacteria gain access to the milk they begin to develop very rapidly. Milk at the natural temperature of the body is a most suitable medium for their development. One form feeds on the sugar, the result of which is that lactic acid is produced. This is the natural souring or ripening of the milk; and, in cheese making, it is the adjustment of the various processes of manufacture to the development of the lactic acid that influences the matured product for good or ill. When proper precautions are taken with regard to cleanliness, the majority of germs that get into milk are of the class already mentioned, viz., those that produce lactic acid. When due attention is not paid to cleanliness, various filth germs get into the milk. These, feeding on the casein and other albuminoids, produce gases which form the pin holes and round holes in the curd and develop taints and bad flavors. A great variety of bacteria may get into the milk if proper care is not taken to prevent them. If they are subjected to high temperatures, say 130 deg. Fahr., and upwards, for a lengthy period, they will be destroyed. Low temperatures will check their development, so that by cooling the milk they are kept in check, and the development of acidity can be controlled by the cheesemaker.

The predominance of any particular class of germ in the milk has the influence of overpowering or keeping in check those that are in a minority; hence the use of pure cultures of the lactic acid bacillus which are



Milling the Curd.

known as starters. These starters are prepared from a pure culture supplied in a liquid form by the Department of Agriculture or from commercial cultures obtainable from the agents in the form of powder.

### NECESSITY FOR CLEANLINESS.

As in all branches of dairying, cleanliness is of the greatest importance in cheese making. Sufficient care is not devoted to the raw material by those who milk the cows and handle the milk before it is delivered into the factory, and it is at this stage that it is more liable to contamination from careless and uncleanly habits.

The cows must be provided with a clean water sup-



Cheese-maker Taking the Acidity Test at the Coagulating Tank.

colonies. In the United States, in 1830, cheese was sold in the local markets at 5 cents to 8 cents per pound. From 1840 to 1850, the Americans began to ship it to Britain. In 1851 the factory system was inaugurated, and by 1866, 500 factories had been built. For the season ended September, 1859, 7,542 tons were exported. From that date the exports increased rapidly, and for a long time the Americans had the British market almost to themselves. Canada then entered into the business.

The original system was somewhat complicated, and it required a large amount of experience to produce a cheese of good quality. Even then troubles that puzzled the most experienced makers would affect the quality. The Canadian experts developed a modification of the system under which, by following fixed rules, more certain results are obtained and a more uniformly good article is produced. This is now known as the Canadian Cheddar system; and by it makers of limited knowledge are enabled to achieve greater success than was formerly possible by the most experienced under the American or "Stirred curd" system. The Canadian cheese trade soon grew to one of great proportions, and the quality was such that it commanded the highest prices. Owing to the rapid increase of population in the United States, the exports from that country have decreased till they have now little influence on the trade.

The system was introduced into New Zealand, but for many years the export trade was at a standstill, while the butter exports forged ahead. In 1907, however, owing to various reasons, the demand for cheese increased and uniformly good prices were obtainable,



Drawing Whey Off the Mat.

As the following figures show, the New Zealand cheese export trade was steadily developed:

### NEW ZEALAND CHEESE EXPORTS.

1905 .....	\$ 904,370
1906 .....	1,325,420
1907 .....	2,248,380
1908 .....	3,961,590
1909 .....	4,327,280
1910 .....	5,928,520
1911 .....	6,111,820

The Canadian system was introduced into Victoria

\* Reproduced from the *Journal of Agriculture, Victoria*.

ply. If the supply is obtainable from the open dam, this must be fenced so as to prevent the cows polluting it with their own droppings. The mud thus contaminated sticks to the udders, and it is almost impossible to prevent some of it finding its way into the bucket while milking.

It must be borne in mind that dung in any shape or form is the worst form of contamination to which milk is exposed. For this reason, the yards and sheds must be kept clean; and, particularly in the summer, dry cow dung must not be allowed to accumulate about the yards. The cow shed and milk room must be regularly limewashed.

The cows' udders must be washed or wiped with a damp cloth. This is especially necessary in the spring time, or when the animals have a full supply of succulent fodder, which has a laxative effect. Extra care is then necessary to prevent contamination.

The milkers' hands should be washed before milking each cow. For this purpose, water may be provided in a five or ten-gallon oil drum, with a tap. Dissolve some Clady's crystals in the water. This will help to prevent the spread of sore teats or other troubles due to germ life.

Only well tinned utensils should be used. As the tin wears off, giving rise to a rusty appearance, they must be re-tinned or replaced by new ones. The utensils should be cleaned by first rinsing with cold or lukewarm water, and then thoroughly scrubbed with hot water in which soda has been dissolved in the proportion of about one-half pound to 10 gallons of water. Afterward scald with boiling water and soda, steam thoroughly, and place upside down to drain and dry. A cloth should never be used in cleaning the utensils—always use a brush.

#### CARE OF MILK.

The milk should be strained through a "Ulux" strainer, which consists of wire gauze, and wadding disk which is burnt after use. If butter cloth and wire strainer are used, take a fresh piece of butter cloth for each milking and double it.

The night's milk should be removed from the shed to a clean milk room and run over a cooler to remove the animal heat; the reduced temperature also checks the development of bacteria and prevents the milk becoming over-ripe.

Before the milk is emptied into the receiving or making vat, it is the duty of every maker to examine the milk as to its condition. Thorough work at the receiving platform places one on the high road to success in the labor that follows. While the milk is being received into the vat, it should be stirred gently at intervals to keep the cream from rising to the surface. Use the thermometer to ascertain the temperature of the milk. If over 70 deg. Fahr., do not apply the steam until you are sure that there is enough milk near at hand to fill the vat. If there is a suspicion that the milk is over-ripe, test is for acidity, as described below, or make a rennet test; if it proves to be over-ripe, the whole process must be hurried on to keep ahead of the acid. If, on the other hand, the milk is found to be fresh and sweet, a good starter must be used. Should there be any bad flavors evident, a good starter will assist in overcoming them.

#### STARTERS FOR CHEESE MAKING.

In preparing starters from commercial cultures for cheese making, it is essential that all vessels be washed and scrubbed in tepid water and soda and then thoroughly rinsed with hot water and soda, and sterilized with steam.

It is advisable to get the best milk obtainable and as fresh as possible from cows that have not advanced too far in their period of lactation. The milk should be strained through a Ulux strainer before putting it into the can or bucket in which it is scalded.

Stand the vessel in a trough of water heated by steam. Keep the water boiling slowly to prevent any water splashing into the milk. In this way the temperature of the milk is raised up to nearly boiling point (say 200 deg. Fahr.) and should be maintained at that temperature for half an hour, stirring occasionally with a clean sterilized rod.

Take the can out and strain the milk into a clean vessel, and wash the can first with cold water and then hot water and soda, and sterilize with steam.

Take one gallon of the scalded milk and cool down to 80 degrees, when the culture may be added, stirring it in thoroughly with a clean glass rod.

Cover the top of the vessel with a piece of clean cheese cloth that has been scalded and dried, to prevent any flies or dust getting in.

Set the can in a tub of water at a temperature of 78 degrees, giving the milk a stir for the first 5 hours at intervals and maintaining that temperature from 18 to 24 hours. The startline should be nicely thickened; skim off about 2 inches and discard it. Stir it up with a clean glass rod till it becomes like cream and keep back one pint to be used to start the second day's pasteurized milk.

The second propagation should be started at a lower temperature (about 180 degrees) and maintained at 70 degrees for the same period.

Test the acidity by using the acidimeter test, which should show 0.65 per cent. Keep back about 1½ pints to be added to third day's pasteurized milk.

The third propagation should be cooled down to from 65 to 70 degrees and kept at that degree from 18 to 24 hours. This propagation will be found sufficient to set the ordinary starter. The quantity to be used for the ordinary starter will depend on the acidity developed, which should not exceed 0.80 to 0.85 per cent.



Pressing the Cheese.

One per cent to 1½ per cent will be sufficient if the starter is mild to the sense of smell, clean and sharp to the palate, and firmly coagulated. If found to be over-ripe, use less.

It is a very important matter that the starter be kept covered and in a pure atmosphere. Before using a starter always reject one inch from the top of the starter which is not so good. The starter should be poured from one vessel to another until it becomes smooth and uniform. If it is found desirable to add the starter to the vat of milk after the temperature has been raised, mix the starter with an equal quantity of warm milk from the vat. After pouring from one bucket to another it may be put into the vat by straining it through cheese cloth so as to prevent the cold starter from curdling or forming into white lumps, causing mottled cheese.

A good clean flavored starter gives the desired flavor, aroma, and keeping quality required in cheese. A poor flavored one should never be used, as it spoils the flavor of the whole vat of milk.

#### THE RENNET TEST.

Heat a small quantity of milk in a dipper placed in hot water, raising the temperature to 84 degrees or 86 degrees. Take a 4-ounce glass measure of the milk and pour into an enamel mug, place in it a small chip or cork, pour in one drachm of rennet, and stir vigorously for 10 seconds with a clean teaspoon or a glass rod; then withdraw the spoon and watch when the



Dressing the Cheese.

chip stops. If the chip stops quickly, the milk is over-ripe.

#### THE ACIDIMETER OR TITRATION TEST.

The acidimeter or titration test is based on the fact that one cubic centimeter of decinormal solution of caustic soda will neutralize .009 gramme of lactic acid.

To make the test, put 10 cubic centimeters of the liquid to be tested in a white cup, and add two drops of phenolphthalein solution, which, by the production of a pale pink coloration, acts as an indicator of the point when neutralization of the acid by the soda takes place. Fill a burette graded in one-tenth of cubic centimeters with the soda solution, but not above the 0 mark. Note the point at which the solution in the burette stands; then turn the tap and allow the solution to run gradually into the milk, stirring with a glass rod all the time. Each drop of the solution produces a pink color, but when stirred it immediately disappears until the soda solution neutralizes the acid,

when a permanent pink coloration is produced. As soon as this point is reached note how far the liquid has run down the burette; and if it has dropped 22 spaces, equal to 2.2 cubic centimeters. The percentage of acid is calculated as follows:

$$2.2 \times 0.009 \times 100$$

10

present.

A quicker and simpler way of making the test is to take 9 cubic centimeters of the liquid to be tested, when the number of spaces of the soda solution used will indicate the percentage of acid present. For instance, say it takes 22 spaces to neutralize the acid, then

$$2.2 \times 0.009 \times 100$$

9

The temperature of the milk does not influence the titration test.

#### VARIOUS STAGES OF MANUFACTURE.

**Commercial Starter.**—A good starter is the foundation of cheese making, as it is composed almost entirely of lactic acid bacteria; and, in adding it to the milk, millions of desirable germs are introduced and help to crowd out the undesirable ones. Use from ½ to 1½ per cent, according to the sweetness of the milk.

Above all, never use whey for a starter. Sour whey always contains undesirable germs, and these will be transmitted from one day's milk to the next.

**Heating the Milk.**—The temperature of the whole milk should be raised to 84 degrees or 88 degrees, according to its richness. In spring, a lower setting temperature and a comparatively larger quantity of rennet should be used. As the season advances, and the milk gets richer, the setting temperature should be raised.

**Testing Acidity of Milk.**—The milk is now tested with the acidimeter test to ascertain its acidity. The acidities which give the best results are 0.22, 0.225, and 0.23, depending on the condition of the milk and the amount of starter used.

**Coloring.**—The coloring depends on the strength used; from 1 ounce to 1½ ounce to 1,000 pounds of milk gives the right color. It should be mixed in half a gallon of cold clean water, and gently stirred into the milk.

**Rennet Test.**—Before setting the milk, a rennet test should be made. From 18 to 20 seconds is the proper time for normal working milk. The time will vary with the season, condition of milk, and strength of rennet. The quantity of rennet used is from 3 ounces to 4 ounces per 1,000 pounds of milk, and it must be diluted with half a bucket of cold clean water to each vat before pouring into the whole vat of milk. The water delays the action of the rennet for a few seconds.

The rennet should be stirred into the milk with the curd rake or agitator for two to three minutes at a fairly fast rate; then slow down for two minutes so as to have the milk perfectly still before coagulation takes place. Withdraw the rake or blades of the agitator and skim off any dust or fat that may have accumulated on top of the milk. Put canvas cover over the top of the vat to keep the temperature from falling.

**Coagulation.**—Watch for the coagulation of the milk. If this occurs within ten minutes, the curd should be ready to cut in 35 minutes from the time the rennet was added to the vat; or the time it takes to thicken  $\times 2\frac{1}{2}$  from the time it thickens, i. e.,  $10 \times 2\frac{1}{2} = 25$ ,  $+ 10 = 35$  minutes from the time rennet was added.

**Cutting the Curd.**—To ascertain when the curd is ready to cut, wet the forefinger and insert it carefully into the curd and then raise. If the curd breaks cleanly and shows clear whey it is ready for the knife.

The horizontal knife should be used first, lengthwise of the vat. The curd then keeps in place better and allows a more uniform cut to be made with the perpendicular knife. The latter is used crosswise and once lengthwise. The cubes should be even and not over three-eighths inch in size.

The curd should be stirred gently by hand for ten minutes and the curd adhering to the sides or bottom of the vat taken off before applying the curd rake or blades of the agitator.

**Testing Acidity of Whey.**—A test of the whey should be taken before turning on the steam so as to know how the acid is working. With some milks and some starters showing a test of 0.14 per cent, three-quarters of an hour from renneting will bring the curd on quite fast enough, while others, even at 0.15 or 0.16 per cent, may work too slowly in the same time.

**Heating the Curd.**—Steam should be applied through the medium of water under the vat, as there is less danger of scorching the curd. Turn the steam on slowly at first and gradually apply faster as the curd gets firmer. Stir constantly during the heating process, which should take from 40 to 45 minutes to raise the temperature to 98 or 100 degrees as the case may be.

After the curd is at the desired temperature, it should be stirred occasionally to keep it from matting and to insure even and thorough cooking.

**Testing Acidity of Curd.**—If the whey is showing 0.175 in two hours from setting the milk, remove the whey until the top of the curd may be seen; this checks the acidity from getting too far ahead. Mix the curd up by hand so as to get it nice, firm, springy, and elastic, so that when a handful is squeezed together it will fall apart readily on relaxing the pressure, before running the whey off.

If the curd is well cooked, allow from 0.195 to 0.22 per cent of acid before throwing the curd up on the racks in the vat.

Well cooked, curd requires very little stirring as the whey leaves it freely. It is of the greatest importance that the curd be cooked firmly, and that it contain sufficient acid before the whey is run off.

**Racking Curd.**—The curd racks are made in two-foot sections, from 4 to 6 inches in depth, to fit inside the vats. Tilt the vat so that the top end is about six inches higher than the bottom, and draw the curd downward. Put in the first section of rack and cover over with rack cloth. Dip enough curd on to the rack to make space for second rack. This process is continued till all the racks are in place.

Stir the curd gently and level it back 8 to 10 inches deep to mat. Test the acidity of the whey after racking; it should show from 0.285 to 0.30 per cent in 2½ to 3 hours from setting the milk.

**Matting the Curd.**—Put cover over the top of the curd and allow it to mat from 10 to 15 minutes; then cut in strips lengthwise and crosswise in 8 to 10-inch blocks and turn over. Repeat the process until the curd becomes "meaty," and when pulled apart it splits instead of breaking. At the last turn, place the curd on the bottom of the vat and remove cloths and racks before milling, which generally takes two hours from racking. The temperature of curd at this stage should be 94 degrees.

**Milling Curd.**—Knife mills should be used, giving a clean cut three-eighths inch to one-half inch in size. If smaller, they injure the curd, causing unnecessary loss of butter fat and spoiling the texture of the cheese.

**Mellowing the Curd.**—After the milling is completed, the curd should be turned over by hand, and covered to maintain the heat and prevent the curd from bleaching. Repeat the same process every 15 minutes for one hour after milling.

**Testing Acidity of Curd.**—Fifty minutes from milling make a small hole in the center of the curd, so that the moisture will gather sufficiently to allow a test to be made. Aim at 1 per cent of acidity, three hours after the curds are dry on the racks.

Turn the curd over by hand and cover up, repeating the previous process of mellowing. In half an hour the curd becomes soft and velvety, and exudes a moisture of half fat and whey testing 1.05 to 1.10 acidity. The curd is then ready to salt.

**Salting the Curd.**—The amount of salt to be added depends upon the moisture in the curd and upon the length of time for ripening. Moist curd requires more salt than quickly ripening cheese. The rate varies from 2½ to 3 pounds per 1,000 pounds of milk.

If the temperature of the curd is 88 degrees, let the water run from under the vat. The curd should be turned over and spread evenly over the bottom of the vat. Sieve half the salt on the curd and stir up thoroughly and evenly through the mass. The remainder should be put on and also well mixed.

**Piling the Curd.**—Pile the curd up in the center of the vat so as to allow the whey to escape. The temperature of the curd at this stage should not exceed 84 degrees. Cover the curd over for 20 minutes until the harsh feeling caused by the salt has disappeared; mix the curd up by hand and it will then be ready for the hoops.

**Dressing Cheese Hoops.**—In the bottom of the hoop place a clean cap cloth (hessian preferred). Use two cloths (seamless bandage). Wet the first cloth before putting it on, and do not have any on the bottom. Put the other cloth on and lap about 1 inch on the bottom of the hoop and cap cloth. When two cloths are used a silky skin is put on the cheese. The outside cloth is taken off in the morning and washed ready for the day's hoops.

**Hooping the Curd.**—The curd is now firmly packed into the hoops and weighed, and put into the press with the jointing of the inner hoops facing the gutter of the press.

**Pressing the Cheese.**—At first, the pressure should be applied gradually to the curd. When the whey starts to come away freely, stop screwing for 10 to 15 minutes; then screw up, repeating this process for one hour. A quarter of an hour before dressing the cheese, pour three or four buckets of water gently over the hoops at a temperature of 130 degrees, to assist in putting a good rind on it.

**Dressing Cheese.**—After about one hour has elapsed

the cheese should be removed from the press, and the operation known as dressing the cheese performed. This consists of trimming round the edge of the cheese, wetting the cap cloth with clean hot water, and pulling up the bandage and removing wrinkles so that the binding will lap one-half inch over the end. Wet the outer cap cloth and replace the cheese in the press, joining the inner hoops on the top. Pour three or four buckets of hot water on top of the hoops and gradually screw up fairly tightly. The maximum pressure is not put on until late at night.

The cheese should be turned in the hoops, end for end, and the outer bandage taken off in the morning, and any defects in appearance remedied. They are again returned to the press and allowed to remain in the hoops until they are required for the day's cheese. The outside bandage should be washed in hot water and spread over the top of the hoops to air and dry, so as to be ready for use when required.

After being taken from the press, the cheeses are removed to the maturing room to ripen.

**Maturing.**—The cheese should be turned every morning on the shelves in the maturing room, which should be well ventilated. The cheese shelves should be kept scrupulously clean and thoroughly washed at the end of the season with boiling water and washing soda. This keeps the cheese clean and helps to prevent mold. The floor also should be scrubbed and kept clean. Clean and neat cheese placed evenly on the shelves gives the room a nice appearance.

Hoops and presses should be washed thoroughly once a week, and cap cloths should be kept clean and sweet. The cheese vats, curd racks, curd cloths, etc., need special care in washing in order to keep them in first class condition. Curd racks should be left outside and well aired.

Keep the temperature down as much as possible during spells of hot weather, as overheated cheese loses flavor, discolors, and becomes bitter.

With cheese, as with everything else, every effort must be made to please the eye. Marketing cheese that are of unequal height or are lopsided, or the cloths of which are loose from some defect or carelessness in the process of making, is always unprofitable. Not only should the cheese be put up in a neat attractive form, but it should not come in contact with anything having a bad odor.

#### DAILY RECORD.

The cheese-maker should keep a careful record during the various stages of manufacture. A chart embodying the following list will be found very helpful:

1. Milk, ..... pounds.
2. Acidity.
3. Fat test.
4. Starter used, per cent.
5. Temperature of milk before testing.
6. Color, ..... ounces.
7. Rennet test.
8. Acid test.
9. Rennet added, ..... ounces.
10. Temperature set at.
11. Time set.
12. Time stirred.
13. Time to coagulate.
14. Time to cut.
15. Acidity of whey after cutting.
16. Time heat applied.
17. Acid of whey in 1½ hours.
18. Temperature cooked to.
19. Time cooked.
20. Acid in 2 hours.
21. Acid in 2½ hours.
22. Hot iron test.
23. Run whey off top of curd.
24. Curd in whey, ..... hours.
25. Acid of whey before racking.
26. Curd stirred dry on racks.
27. Acid of whey after piling.
28. Cut and turned in 15 minutes.
29. Left to mat, ..... hours.
30. Time milled.
31. Time curd left.
32. Acid of whey one hour from milling.
33. Time curd left before salting.
34. Acid of whey when salted.
35. Temperature of curd when salted.
36. Amount of salt.
37. Time of hooping.
38. Temperature of curd when hooped.
39. Time hoops in press.
40. Time started pressure.
41. Time dressed.
42. Time full pressure.
43. Pounds of cheese.
44. Amount of cheese per pound of milk.
45. Weather conditions (temperature, humidity, etc.)

#### FAST WORKING CURDS HOW TO HANDLE.

During a spell of warm weather the milk, as a rule, arrives at the factory or dairy in a very unsatisfactory

condition. The heating should be so regulated as to have the desired setting temperature attained shortly after the last milk runs into the vat. A rennet test should be made before heating is completed by warming a sample up to the proper temperature. This indicates at once how far acidity has developed, and enables one to regulate the treatment accordingly. When milk is found to be working fast a lower setting temperature should be used, and a larger quantity of rennet added, so as to get the curd ready for the knife as soon as possible. At a lower setting temperature, acidity does not develop so fast. Cut the curd finer, giving an extra cut with the perpendicular knife.

The object is to get the pieces smaller so that they may expel their moisture more rapidly. When the curd gets a little firm, say 92 degrees, remove a portion of the whey in order to control the development of acid, and add 3 per cent of pure clean water at the same temperature as the whey.

In bad cases, all the whey can be removed down to the top of curd, and a second water added. This is found beneficial, as it checks the acid and allows a firm curd to be made before dipping on the racks.

#### GASSY CURDS.

The presence of gas is generally noticed by the slow ripening of the milk. Strong putrefactive fermentations (or taints) are also discovered as the result of examination at the receiving can and milk vat. In such cases, the milk should be ripened at a lower temperature, and more acidity allowed to develop before setting. Do not cut finely; aim at having the cubes larger so as to retain the moisture. Stir longer before turning on steam; heat slower than with ordinary curd. If very gassy, hold temperature a couple of degrees lower, say at 94 degrees, until the acidity begins to develop. This prevents the curd from getting too firm before the acidity is present. When, however, the acidity is coming on nicely, the temperature should be raised to 98 degrees so as to get the curd properly cooked before dipping.

Always allow more acid to develop in the curd before drawing off the whey; do not stir too dry. If well cooked, leave the curd on the bottom of the pan instead of racking. A shade more acid in the whey and more moisture left in the curd will assist in checking the gaseous fermentation of the latter. If the gas continues to check the acidity, and the curd is still working slowly, cut the curd in larger pieces than usual. These will retain the moisture and temperature better, and thereby aid development of acidity. If, on the other hand, too much moisture is present and acidity is developing too rapidly, cut the pieces smaller, mill earlier, and mature well before salting. When the curd has flattened out, all holes have disappeared, and the flavor is fairly clean, salt heavier than with ordinary curds. This will assist in retarding the effects of the bad flavor as the cheese ripens.

#### FAULTS IN CHEESE.

**Acid Flavors** in cheese are due to ripening the milk too much before adding the rennet, using too much starter and not firming the curd sufficiently before drawing off the whey. Prevent the development of too much acid in the milk before renneting. Of no account should sour milk be accepted from any supplier.

If the milk is found to be well advanced, keep back the starter till ready to add the rennet to the vat of milk; use very little (from ¼ to ½ per cent) according to the condition of the milk.

**Rancid Flavors** are due to filth germs caused through allowing cow manure and dust to gather in the cow-balls, and also by impure air where the milk is kept over-night in badly ventilated rooms. Utensils and straining cloths that have not been thoroughly washed and scalded, and bad flavored starters, should not be tolerated.

**Bitter and Yeasty Curd** are due to receiving milk in cans in which sour whey from dirty tanks is returned. All whey tanks should be constructed to allow whey to be carted away and the tank washed out thoroughly daily with hot water, and plenty of fresh air let in.

Whey that has been pasteurized is much better for feeding young calves and pigs, and does away with the sour disagreeable odor so hard to get out of the cans.

**Weak Body and Open Texture** are entirely due to faulty methods of manufacture, and there is no one else to blame but the cheese-maker. The body of the cheese is determined very largely by the condition of the curd at the time the whey is removed. If the curd at this stage is soft and tender, the probabilities are that the cheese will be short and tender in the body.

If the acidity is allowed to over-develop while the curd is in a soft condition, a more or less sour cheese will be the result. It is not the amount of acid in the curd at the time the whey is run off that indicates whether a cheese will be sour or not, but rather the condition of the curd as regards firmness when the acid develops.

**Openness in the Cheese** is due to not allowing the curd to mellow down sufficiently before adding the salt

and putting into press too soon. A sweet cheese is always open, because it resists the pressure and puffs and swells after removal from the press.

**Mottled Coloring.**—An uneven development of acid and moisture in the curd. This can be avoided by uniform cutting, heating and stirring, using three-eighths horizontal knife first lengthwise of the vat and then cutting with the three-eighths perpendicular knife crosswise of the vat and lengthwise. Mix the curd up by hand and then give it an extra cut lengthwise of the vat, giving a smaller cut which makes it much easier to get the curd firmed.

Starters should always be strained through a layer of cheese cloth and added to the vat of milk before the coloring.

The curd left over from the previous day should be placed in the corner of the vat after the day's curd has been piled up on the racks. The drippings from the curd will warm it up. Drain off the curd before milling, pull the curd into a heap, and salt apart. When hooping the fresh curd, put the stale in the bottom of a hoop.

The chief advantage of matting the curd is to improve the texture and body of the cheese. The curd

must be turned frequently on the racks in order to prevent the whey forming in pools on the curd.

The effects of salt on curd are to expel the moisture; to improve flavor, body and texture of the cheese; to retard ripening or curing and to add keeping quality to the cheese. If salt be applied to the cheese before it become velvety, the quality of the cheese is not so good.

A really fine cheddar cheese should have a clear pure silky and firm appearance when drawn by the trier. There should be no stickiness or pastiness on touching it; neither should there be any holes in the meat, or streakiness in the color. It should be pleasant to the eye, and sweet to the nose and the palate.

#### TRADE TERMS.

**Flavor.**—In common with other edible commodities, flavor is of the utmost importance in cheese. The flavor of high grade cheese is agreeable to the palate, is nutty, clean, and devoid of any bitter or objectionable after-taste.

**Texture.**—Perfect texture is shown when a plug or cut surface of the inside cheese presents a solid, compact appearance, free from breaks or holes.

**Body.**—This term refers to the consistency, firmness,

or substance of the cheese. Perfect body is indicated by its being solid, firm and smooth in consistency.

**Coloring.**—The color varies according to demand on the market.

#### EXPORT CRATE.

The cheese crate should be neat, strong and tight, the timber being well seasoned, and dressed both sides and ends. A further improvement in appearance is effected by bevelling the edges of the battens. Green timber should never be used, as it causes the rind to become softened, and is liable to impart a bad flavor to the cheese, and to occasion the development of mold. Care should be exercised to get the crates as nearly as possible the same size as the cheese, or, in other words, the cheese should be made of a uniform size to fit the crate.

When this is done, they look neater and are prevented from moving about. The packages also take up less space and unnecessary surplus weight is avoided.

The partition between the cheese should be securely nailed, and the ends of the crates bound with 14-gauge pliable wire, with  $\frac{1}{2}$ -inch staples, or galvanized iron hoop ( $\frac{3}{4}$  inch).

## Skis; Their Construction and Use

### The Making of a Good Ski is a Delicate Task

IN many mountainous regions, especially in the far north, the ground is so deeply buried in snow for weeks and months in winter that driving, riding and ordinary walking are impossible, and locomotion can be accomplished only with the aid of snow shoes. The principal types of these devices are the Canadian latticed snowshoe, which closely resembles a tennis racket, and the Norwegian snowshoe or ski, which is a long, narrow and slightly curved plank. The form and dimensions of the ski vary according to the particular use for which it is designed. In general, the length is approximately equal to the height to which the wearer can raise the tips of his fingers, and consequently ranges from  $6\frac{1}{2}$  to  $7\frac{1}{2}$  feet. The width varies from  $2\frac{1}{2}$  to 4 inches at different points, and the thickness varies (inversely to the width) from one-half inch to  $1\frac{1}{4}$  inches. Fig. 1 shows the plan and longitudinal and transverse vertical sections of a ski of the usual type. The upward curve of the front end is permanent, but the slight convexity of the after portion, on the crown of which the foot rests, is flattened in use by the weight of the body. The curve is determined by the elasticity of the wood and the weight of the wearer, so that the main part of the ski shall become perfectly straight under that weight. If the ski were made straight the wearer's weight would give it a concave form which would make locomotion impossible. A longitudinal groove in the under side molds the snow into the form of a rail, on which the ski glides, and which makes it easier to keep the two skis parallel in running or coasting. A mortise is chiseled transversely through the thickest part of the ski, to facilitate its attachment to the foot.

The construction of a good ski is not an easy task, for it involves a number of delicate problems. The following description of methods and details of construction is furnished by *La Nature*:

Skis intended for use in the mountains must be both strong and supple. These two qualities are associated in the wood of the ash, of which most good skis are made. Because of the high price of ash, many mountaineers substitute spruce or larch, which abound in the Alps. Skis are sometimes made of two kinds of wood, a heavy, close-grained species being employed for the lower, and a light wood for the upper part. Very hard and heavy oak is used for the bottoms of leaping skis. A ski made entirely of oak would be too heavy for use. White ash presents the best construction of the four desired qualities of elasticity, strength, lightness and moderate cost. The trees are felled in winter before the sap has started and are cut into planks about 8 feet long,  $4\frac{1}{2}$  inches wide and  $1\frac{1}{2}$  inches thick. Knots are carefully avoided and the planks are so cut that the grain of the wood will run obliquely downward from front to rear of the ski, as is indicated in Fig. 2. The planks are seasoned in the air for one year. The skis are then cut out with the aid of models and the bottom is planed to perfect smoothness. The desired curvature is usually obtained by soaking the ski in water and bending it with the hands or by pressing it in a mold. Dr. Paulcke advises the mountaineer to support the ski, in an oblique and inverted position, with its front end over a charcoal fire. A wet cloth is placed on the part to be bent, and the point of the ski is drawn downward by means of a cord until the desired curvature is obtained. The

cord is then fastened to a fixed object, the wet cloth is removed and the ski is allowed to dry over the fire. Fig. 3 shows how simply this operation can be performed with the aid of an ordinary sledge. The curvature of the after part of the ski is produced by a similar method.

At the normal military school at Briançon, in the Hautes Alpes, the wet planks are clamped between forms (Fig. 4) and are thus dried in a warm, well ventilated room or in a moderately heated oven. This process is expeditious, but is apt to cause brittleness.

In the Hagen ski factory which turns out 100 skis per day the ash planks, which have been kept one year in the storehouse, are soaked ten minutes in boiling water. This treatment makes the wood so pliable that it can be bent by hand on a form. The ski is allowed to dry in the air during two weeks, after which the final curvature is given to it by hand.

The desired curvature having been produced by any of these methods, the longitudinal groove and the transverse mortise are cut, and the ski is polished and varnished.

The problem of attaching the ski to the foot is much discussed and many different methods are employed. The attachment should be strong and simple and should assure easy and perfect control of the ski, without unduly restraining the freedom of the foot. Above all, it must be easy to adjust even with fingers stiffened by cold. It is also desirable to be able to disengage the foot quickly in emergencies to prevent breaking the ski or the leg.

One of the best and most generally employed devices is the Hintfeld attachment by means of iron lugs and a number of straps passing over the toe and around the sole and heel of the shoe, in a manner which will be made more intelligible by a glance at Fig. 5 than by any verbal description. The horizontal strap is provided with a lever buckle *E*, the operation of which is illustrated by Fig. 6. This buckle can be instantly unfastened and the foot can then be drawn out of the harness, which remains attached to the ski.

Persons who are not familiar with skis imagine that they are employed only for coasting, and that walking on a level is very difficult and ascending a slope quite impossible with such footwear. As a matter of fact Mont Blanc and many other lofty peaks have been scaled by ski runners. If the snow is in good condition a grade of 30 degrees can be ascended as rapidly on skis in winter as without them in summer, and in a long climb an average ascent of 1,000 or 1,200 feet per hour can be accomplished. On level ground five miles can easily be covered in an hour. In 1884 the Laplander Luorda traveled 136 $\frac{1}{2}$  miles on skis in 21 hours and 22 minutes.

The ski runner, however, finds his greatest delight in coasting down a long steep slope. The joy of gliding as swiftly as a swallow, with every sense quickened to discover and avoid obstacles, cannot be imagined by one who has not experienced it.

This marvelous sport is becoming more and more popular in the French mountain country, although it is of very recent introduction. In Norway, skis have been employed in military operations since the year 1200, but it was not until the winter of 1901-1902 that the first experiments with skis were made by the French army. The employment of skis by both soldiers and civilians has increased rapidly since the opening of the Briançon Normal School in 1903 and the international ski contest on Mont Genevre in 1907.

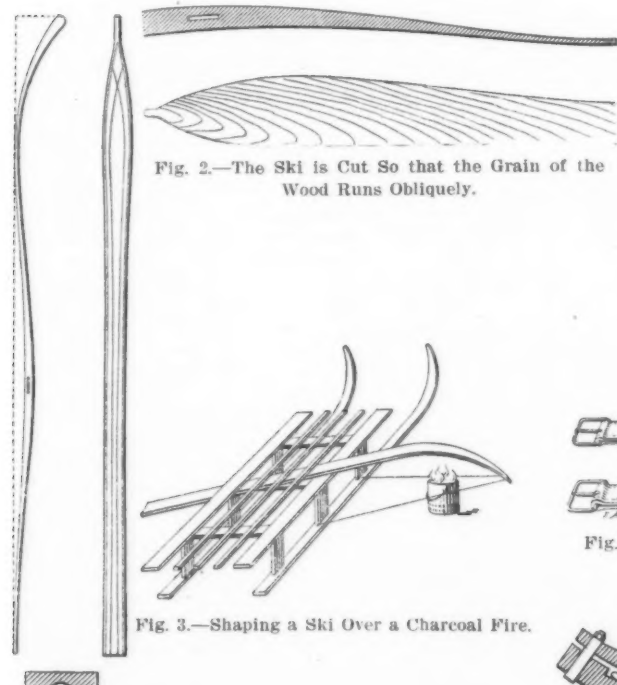


Fig. 1.—A Ski, in Plan, Elevation, and Cross-Section.

Fig. 2.—The Ski is Cut So that the Grain of the Wood Runs Obliquely.

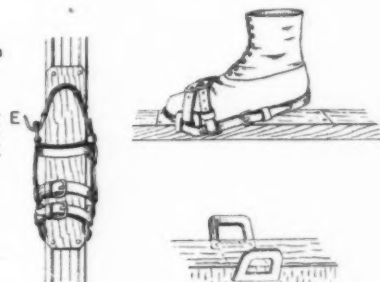


Fig. 5.—Hintfeld System of Attaching the Ski to the Foot.

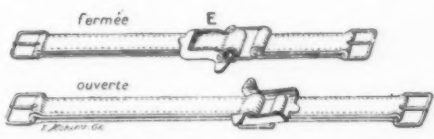


Fig. 6.—The Lever Buckle, Open and Shut.



Fig. 4.—Shaping a Ski by Clamped Forms.

Fig. 3.—Shaping a Ski Over a Charcoal Fire.

# The Sewer System of Havana\*

How the United States Have Fulfilled Their Responsibility

By G. C. Scherer, Asso. Am. Soc. C. E.

BEFORE American occupation, Havana was perhaps one of the most unclean cities, both municipally and morally in the world. It numbered close upon 300,000 inhabitants, with practically no sewer system, at that time.

As Havana had proved a menace to the ports of the United States on account of yellow fever, the United States, under the Platt amendment to the Treaty of Paris, became responsible for the proper sanitation of the city.

It was at first intended to use the combined system of sewers, i. e., sewers to carry off both storm water and sewage, but later it was decided to install the separate system, first introduced into the United States by Colonel Waring using concrete sewers constructed in trench. The Meriwether System of reinforced lockjoint pipe was finally adopted.

The estimated cost of the sewage system and repaving was some fourteen million dollars, contemplating about 300 miles of sewers.

Considerable trouble was experienced in obtaining funds for this work. During the four-year term of President Palma's administration, and also during the short time he was president on his second term, no money was provided. When the United States intervened and placed Cuba under a provisional governor, the United States ordered ten per cent of all the customs duties of Cuba to be set aside for use in sewerage of the city. The annual income from customs duties averages \$20,000,000, therefore \$2,000,000 was made available for this work each year. Later the Cuban government issued \$16,500,000 of bonds to be retired by the sums set aside from the yearly customs duties.

The lack of hygienic laws in Cuba has possibly been the cause of the severe epidemics of yellow fever that have caused the death of so many in our Southern cities, and it cannot be denied that American occupation has had a more far reaching influence than the casual thinker would ever realize.

The first work of sewer laying in Havana was commenced in the Jesus del Monte district in September,

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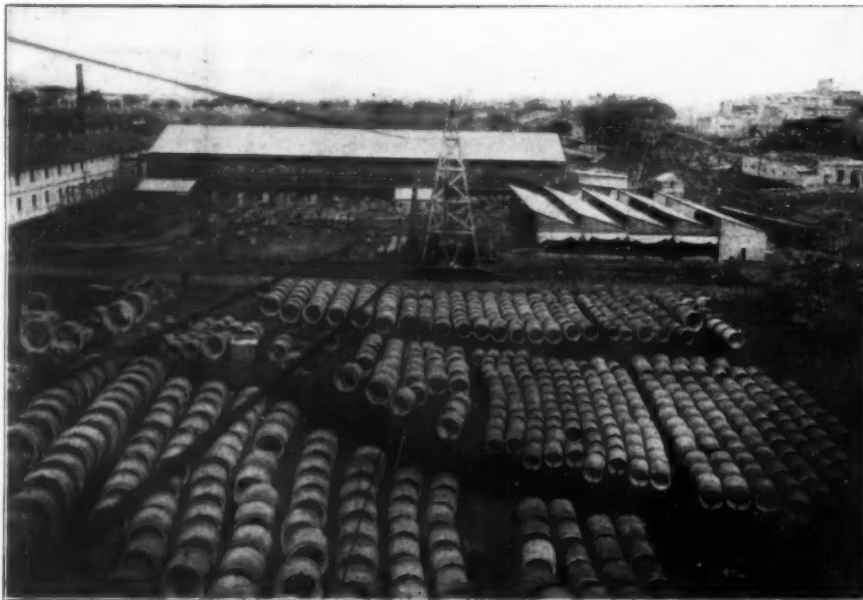


Fig. 1.—A General View of the Main Yard Soon After Starting.

1908, and has been unremittingly carried on ever since. Up to the present some 195 miles of sewer and storm drains have been laid.

The size of these sewers and drains range from 8 inches ( $\frac{2}{3}$  of a foot) to 84 inches (7 feet).

Owing to the narrowness of some of Havana's streets, the placing of 84 inch drains presented quite a problem, (see Fig. 3) where this pipe is being lowered into place in an 18 foot street.

The city of Havana is practically level, particularly that part lying close to the Gulf and the Almardores

River, therefore it was necessary to provide a number of intercepting sewers, and trunk lines which assembled the sewage at a point where a syphon received it and carried it under the harbor of Havana to a chamber in the main pumping plant near Casa Blanca (Castle Cabanas). The sewage from Regla is also assembled there.

The sewage flows into a receiving chamber by gravity. It is then lifted twenty-four feet, in order to give it another fall by gravity, and it is carried thence through a seven foot concrete lined sewer which passes through



By courtesy of the *Concrete Age*.

Fig. 2.—Method Employed in Placing and Removing Pipe in the Storage Yard.



By courtesy of the *Concrete Age*.

Fig. 3.—Electric Telfer Machine for Unloading and Lowering Pipe Sections into Trenches.

Cabana Hill near the fort of that name. Thence through a sub-aqueous discharge of cast iron pipe embedded in concrete. This outlet pipe extends some 500 feet out into the Gulf stream and has its outlet thirty feet beneath the water.

The outlet of this discharge sewer is far enough away from the entrance to Havana harbor to preclude the possibility of its entry into the harbor, therefore contamination of its waters is impossible.

Much of the syphon and outlet pipe is laid in coral rock, and is believed to be exceedingly permanent.

Fig. 3 shows a section of this pipe being lowered into its place in the trenches. This piece is 84 inches in diameter and weighs five tons. Fig. 5 shows an 84 inch section of sewer after completion. The peculiarly target-like effect is rather unique.

It is here that mention of the Meriwether System of lock joint pipe may prove of interest.

This system provides for the manufacture of the pipe in close proximity to the trench, making the proper inspection possible and still insuring prompt delivery. The manufacture of the pipe in the city where it is

to be used carries that much more revenue into the locality by employing local labor.

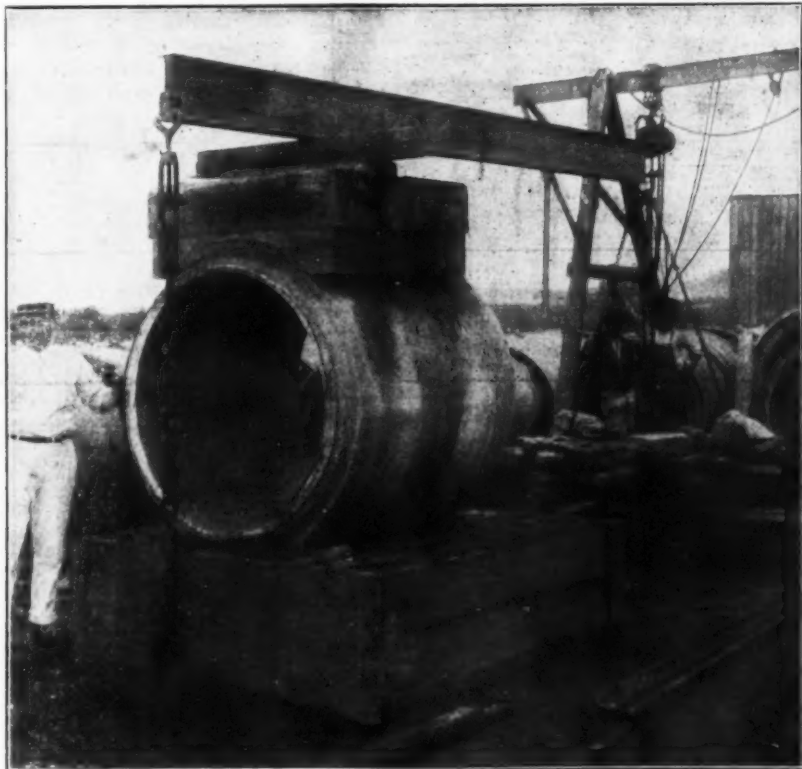
The Meriwether System of Continuous Concrete Pipe is reinforced with various kinds of metal, including triangular mesh, expanded metal and plain or deformed bars, whichever is best suited for the particular size and use of the pipe. This system was the first to use mesh reinforcements for concrete pipes.

A weak or defective joint means weakness—the Meriwether System provides strong joints as a distinctive feature. This is insured by the peculiar construction. The reinforcing metal extends throughout the length of the pipe, and projects several inches beyond both spigot and bell ends. The spigot end is shorter than the bell, therefore when two joints of pipe are engaged, the reinforcing metal in one section overlaps that in the other. The recess where the reinforcement comes together is filled with neat cement, thus locking the joints effectually.

On all pipe 36 inches in diameter, or larger, the joints are made from the interior after the back filling has been placed, by forcing grout behind a shield with a grout gun. On sizes less than 36 inches in diameter the joints are made from the outside through openings in the crown portion of the bells before the back filling is placed. By placing the back filling before the joint of the larger pipe is sealed, any settlement caused by the fill will occur before the joint is made, thus any strain on the joints that would tend to injure their efficiency is eliminated.

Thus it will be seen, that the Meriwether System provides for a continuous reinforced concrete pipe, laid in sections, in which the joints between sections are so made as to insure freedom from leakage or obstacles to flow.

**An Aeroplane Propeller Test Plant.**—A 75-horsepower adjustable-speed motor is used by the Worcester Polytechnic Institute for testing aeroplane propellers in its new experimental plant. The propeller is mounted at one end of a centrally pivoted 160-foot beam and, driven by the motor, propels the beam against the adjustable resistance interposed by paddles which can be let down into the water of the lake in which the plant is mounted. To simulate flight conditions further, a second motor will be installed to drive the beam at a tip velocity of sixty miles per hour. The thrust exerted by the aeroplane propeller and the power taken to drive it under various conditions are measured by recording instruments on the rotating beam.—*Electrical World*.



By courtesy of The Concrete Age.

Fig. 4.—Crushing Test of Sewer Pipes.

With the general recognition of concrete for building purposes there has come a fuller appreciation of its possibilities in sewer construction. Concrete is acknowledged to-day as the most indestructible of all material for that purpose and as a result has been adopted for general use in all large cities.

Havana is blessed with a most abundant water supply which is carried for some eighteen miles in an immense aqueduct of stone from the base of the hills which traverse the Island of Cuba almost from one end to the other. This water is filtered seven times before it reaches the city, and as there are no meters, the water is freely used by the inhabitants, not only in their homes but in the many factories throughout the city.

This means that Havana sewers are forced to take care of a very great flow. Add to this the heavy burden placed upon them in carrying off the storm water from the streets in the rainy season when torrential rains occur each day, and some idea of the vast volume of water and sewage may be gained.

Every pound of cement used in these sewers is manufactured in Cuba. Just outside of Havana a very deep river makes its entrance into the Gulf Almardares on the banks of which a large cement factory is situated. An inexhaustible quantity of material for the manufacture of cement of the finest quality is found ready at hand.

The company owning the plant has a capital of \$1,375,000. The capacity of the plant has been twice doubled and its present output will be again doubled within a short time.

Fig. 1 shows the manufacturing plant and store yard where the pipe is made and stored until required for use. The means of distributing it is somewhat ingenious and merits more than passing notice. On each side of the yard is erected a tower (one of which is shown in the center of Fig. 1). These towers are placed on railroad tracks and can be moved from one end of the yard to the other. They are connected by a heavy overhead cable upon which a trolley runs, and the pipe is then slung as shown in Fig. 2 in a sort of saddle, and carried to the point desired and gently lowered into place on the ground.

Fig. 4 shows the manner of testing each piece of pipe.

Note the great saddles of wood hollowed out to receive the convex form of the tile. This allows an equal pressure to be exerted, and the pipe that withstands this pressure without collapsing is passed as perfect.



By courtesy of The Concrete Age.

Fig. 5.—View of Inside of an 84-inch Pipe After Completion.

# Wheels, Ancient and Modern and Their Manufacture—I.\*

## From Tree-trunk Roller to Wire-spoke Motor Car Wheel

By Henry L. Heathcote, B.Sc.

### SCOPE OF THE PAPER.

The object of this paper is to present an account of some of the most ancient and most modern wheels, to describe their form, the materials used in their construction, and, as far as possible, the methods employed in their manufacture.

To prevent the account becoming too sketchy, it will be limited almost exclusively to vehicle wheels, and no attempt will be made to follow the application of wheels in the many arts which employ them.

The important advances which were made by the ancients when they began to employ wheels and rotating members in their mechanical contrivances, and the manifold latter-day developments and arts in which they are indispensable, form a chapter so vast that I have not attempted even the briefest summary.

Wheels for facilitating transit are therefore my theme, and no apology need be proffered for an account of what was one of the primitive inventions of mankind, and is of prominent importance to this day. There is a humanitarian as well as a scientific interest in this study of wheels. Throughout the ages, the use of wheels has played a crucial and ever-active part in the development of the means of intercommunication, now become so rapid and frequent as to form the ineradicable and predominating feature of our time. We know now how closely rapid intercommunication and civilization are bound up together. Bearing this in mind, one need feel no compunction in drawing inferences as to the degree of civilization of the ancient peoples from their wheels. The ancient Egyptians employed wheel vehicles for many purposes, and particularly for war, but the Israelites they held in bondage had no chariots at that time. This stood them in good stead when crossing the Red Sea; the Israelites crossed safely on foot, but, according to Holy Writ, the wheels of the Egyptian chariots became (taking the marginal reading) bound so "that they drove heavily." This, which happened about 1490 B. C., is the earliest record I have found of wheel trouble, but for which the Israelites might never have reached the Promised Land.

### ORIGIN AND EVOLUTION OF THE WHEEL.

The actual origin and inventor of the wheel are lost in the mists of antiquity. The use of it appears to have originated in the East and spread westwards. Doubtless the nomadic tribes would be among the first to discover the advantages of wheels. This may account for their widespread use at a very early date. The oldest Indian literature mentions wheels, showing their use as parts of vehicles as far back as 1700 B. C. This is about the date of the first reference to wheels in Holy Writ.

Those who seem most competent to judge, agree that the wheel took its origin from the cylindrical tree-trunks which were placed as rollers under a load. Probably the first vehicle was the sledge, the rollers being used when heavy masses had to be drawn. Rollers being in demand, and heavy ones being difficult to handle, it is likely that long ones were cut up to make small ones. The desirability of fixing these would soon become felt. Precisely how this was done we do not know, but conjecture suggests that the middle may have been grooved out to permit of a staple or pegs on the sledge engaging with the groove and preventing it running along or sideways. This groove may have come to extend the whole width of the sledge. A natural sequence would be to build this form up out of three parts—two disk-wheels and one axle, the axle being prevented by pegs from rolling away underneath the cart. Solid wheels were used by the less civilized nations of Asia Minor, and on the farm-carts of classic times. Virgil refers to solid wheels built up of three planks held together by an iron hoop, and this form is said to be still in use in Southern Italy and to make a loud creaking noise as it turns. Some of the old Chinese pictures show solid wheels with holes cut out, possibly for lightness, but more probably to admit a pole for skidding the wheel on a decline. This is an ancient method of braking, from which has arisen the phrase, "to put one's spoke into another man's wheel."

As late as thirty years ago bullock carts were in use in Lisbon with only two such pegs to keep the axle in position. The body of the cart could be lifted right off the wheels, and even now solid wheels and axle are hewn in one piece out of tree trunks and used for carts in the northern provinces of India. Solid wheels with iron axles are also used.

Splitting must have been a serious cause of trouble in ancient disk wheels. Some that are still extant, dating from 1550 B. C., show bad splits and leathern thongs binding the parts together. Segments of tree trunks would necessarily have a limited diameter, and though

the large ones would prove better runners on rough roads they would be more likely to split. This may have led to planks being nailed together, some crosswise, and the survival of the fittest would account for their persistence. From this to radial planks cut parallel to the grain is not a long step, and from radial planks to spokes is a natural sequence.

### CHARIOT WHEELS.

We will now consider some of the early wheels a little more closely. The use of these for chariots led to a very advanced development even at a very early date.

The invention of chariots is ascribed by some to Erichthonius, son of Hephaestus and King of Athens, who flourished about 1460 B. C.; by others to the priest Trochilus or his son, Triptolemus. Homer described Telemachus as traveling from Pylos to Sparta in a chariot provided for him by Nestor:

"The rage of thirst and hunger now suppress'd,

The monarch turns him to his royal guest;

And for the promis'd journey bids prepare,

The smooth-haired horses, and the rapid car."

Probably, however, chariots had long before this been in use among the Egyptians. In Holy Writ we find two references to Egyptian chariots in use about 1715-1705 B. C. Chariots were, with very few exceptions, two-wheeled vehicles.

### DESIGN OF EARLY WHEELS.

*Egyptian Wheels.*—The Egyptian chariots, as shown by their sculptures, were easily carried by one man, and were, therefore, quite light. It is worth noticing, too, that the wheels were placed as far back as possible. In this position part of the load is borne by the horses. Since the chariot was so light this design could scarcely have been chosen to save them; the object must have been to lessen the load on the wheels and to reduce the shock transmitted to the rider.

The Egyptian war chariots generally have six spokes, a few have eight, and others twelve; their private cars had only four. The spokes were usually round. The felloes were strengthened at the joints with bronze or brass bands, and the rim was a metal hoop. An Egyptian wheel has been found having a wooden tire in six butt-ended segments, and a felloe in six segments lapped at their ends. The rim segments have four slots near the felloe, and bands of raw hide are passed through these slots to bind the rim and felloe segments together. The spokes are round and tapering near the nave, and square and tapering near the rim. They are provided with dowels at each end and a slot near the nave end, probably for a metal band. The diameter of this wheel is 3 feet 1 inch. In Egyptian wheels the axle-trees do not rotate, and the wheels are kept on by small linch pins.

One of the Egyptian paintings in the British Museum shows a wheel with a nave in one piece and sockets for the six round spokes. At the end of each spoke is a T-piece, which forms a socket both for the spokes and for the segments of the tyre. There is also an Egyptian wheel in the British Museum. This is of wood, disk-shaped, flat on both sides and probably formed part of a cart or truck used about 1550 B. C. It is still in excellent preservation and is about 2 feet in diameter, about 7 inches thick, with a cylindrical hole at the center about 7 inches in diameter. It appears to have been cut from a solid tree-trunk.

*Assyrian Wheels.*—The Assyrian sculptures show three forms of wheel: (1) Four-spoked, with heavy rims and tyres for heavy carriages. Some of the hand carts shown in the sculptures have four very broad spokes, which look like boards. (2) Eight-spoked, with three concentric rings in the rim, the outermost being the tyre proper, and spokes fitting into sockets at the nave. These were for chariots. (3) Wheels with nail tyres. Occasionally we come across Assyrian wheels with twelve spokes.

In one sculpture appears the hunting chariot of the Assyrian king, Assurnasirpal. The wheels are comparatively small, probably not more than 2 feet in diameter. You will note how very massive the tyre parts are in these wheels. The six spokes are comparatively slender. This suggests that they were either made of metal or that they presented their edges toward the outside. The tyres are generally built up of four, five, or six segments, the joints being sometimes at the spokes and sometimes between.

*Persian Wheels.*—The Persian reliefs also show an advanced development. One of these shows a wheel with twelve ornamental spokes fitting into a rim carrying a studded tyre. These studs were doubtless intended to keep the metal tyre on the wooden felloe, but their number suggests strongly that, even in those very early times, they appreciated the need for some non-skid device.

Among the discoveries in South Germany are some

iron tyres, all that remains of the chariot buried with some dead warrior. These tyres are about 40 inches in diameter, and are covered with radial spikes on the inside. On the outside are still left the overlapping scale-like heads of nails, just like the Assyrian and Persian tyres already referred to.

Cyrus, King of Persia about 560 B. C., made several improvements in chariots and chariot wheels. We are told that he noticed how easily the wheels broke and built them stronger. He lengthened the axle to give chariots more rigidity, and at each axle end of the war-chariots he fixed a horizontal scythe, and underneath the chariot other scythes with their points turned toward earth.

*Grecian Wheels.*—The Greeks preferred wheels with four spokes. Some Greek vases (800-500 B. C.) show racing chariots with wheels having four flat spokes. A terra cotta relief of this kind shows Paris abducting Helen. This wheel is very crude as compared with the approximately contemporaneous Assyrian and Persian examples. The flat side of some Grecian spokes is wider at the nave than at the rim and parallel to the axle. Strengthening pieces appear always to be used at the junction of the rim and spokes, and the tyres are in segments—generally four or more—of flexible wood kept in place by an outer iron tyre. One vase (about 700 B. C.) shows a racing-chariot with two spokes, and two bars at right angles to these from one side of the rim to the other, but not passing through the nave. These wheels were made to rotate on the axle. The nave had an external ring of iron into which the spokes fitted, and a flat ring supported by a linch-pin prevented the wheel from coming off. Their diameter was for the most part under 30 inches, and the two wheels were nearly 7 feet apart.

### MATERIALS USED IN ANCIENT WHEELS.

The early Egyptian carriage-wheels were made of wood, and some of these are still in existence. Their sculptures show their methods of bending the felloes and rims, spoke-making and wheel-building. The spokes were shaved to make them round and smooth. The Egyptians knew how to produce iron as far back as 3733 B. C., but it was among the Assyrians that this metal was most freely used for the production of tools, weapons, and ornaments, and the Egyptians probably learned many of the uses of iron from them. We have already seen how the Assyrians applied their skill in metal-working to wheel-making, and doubtless their progress in this direction is closely connected with their military success.

According to Holy Writ, the wheels of Solomon's laver carriages (about 1000 B. C.) were bronze. We read: "Their axle trees and their navies and their felloes and their spokes were all molten." At the time of Judah (about 1440 B. C.) we read of the dwellers in the valleys of Palestine having chariots of iron. This probably refers to forged iron; cast-iron was probably not known till after the time of Homer (about 900 B. C.). The first Grecian wheels were made of oak. The later Grecian wheels were made entirely of bronze. Homer speaks with enthusiasm of copper tyres (Iliad 5, 722 *et seq.*): "Quickly Hebe fixed on the chariot the rounded wheels of copper, eight spoked, around an iron axle; their felloes were indeed of gold, imperishable, but around tyres of copper were firmly fitted, a wonder to behold."

Whether this was a detachable spare wheel that the Goddess of Youth was fitting to the chariot we are not told, but it is interesting to note how gold felloes pale into insignificance beside copper tyres that did not easily come off.

There are some antique bronze chariot wheels still in existence at Toulouse. These are 54 centimeters in diameter, and have navies 40 centimeters long and 7 centimeters in diameter. The spokes are five in number, and there are deep recesses in the felloes to take the tyres. The rivets used for fastening on the wooden tyres can still be seen in the felloes.

Of early British wheels I have no examples to cite. Cæsar, you may remember, found our ancestors possessed of war-chariots which they managed with great skill, implying a long previous acquaintance with the use and manufacture of wheels.

### ANCIENT WHEELS—GENERAL CONSIDERATIONS.

Before leaving these ancient wheels it is, perhaps, worth pausing a moment to consider their main features from one or two present-day points of view—e.g., strength, serviceability, and appearance. In those times torque would only be applied to a wheel in its plane when occasion arose to put the shoulder to the wheel. They were not built to transmit torque, so when the Egyptian wheels sank in the sand of the Red Sea they gave trouble. The same must have happened

\* Paper read before the Royal Society of Arts.

in many other cases. Every time a car or chariot curved to the right or left a thrust on the rim would be developed perpendicular to the plane of the wheel, its magnitude depending on the weight, speed, and flexibility of the car, the radius of the curve and the character of the ground. The tendency of this would be to break the spokes near the nave. In overcoming this there are two paths open to the designer, one is to dish the wheel, the other to strengthen the rim—the former is the modern way, the latter was the method adopted by the ancients. The Greeks, as we have already noticed, provided strength to resist side-thrusts by sometimes employing spokes wider near the nave and, with their flat side parallel to the axle. This was also the method

employed for building one of the London Omnibus Company's wheels which came under my notice a few years ago.

With regard to serviceability, it is probable that these ancient wheels would work loose where the spokes enter the felloe and nave. This would lead to loud creaking and groaning, and probably partly explains why we read of the mother of Sisera listening for the noise of his chariot wheels and not for the sound of his horses' hoofs. No doubt the sockets employed in the more recent of the ancient wheels served to strengthen the joints and minimize the noise.

With regard to appearance, even in very early times they preferred wheels with more spokes (eight and

twelve) for war and state purposes. Where the wealth of Solomon made it possible, bronze wheels were preferred, and among the æsthetic Greeks the all-bronze wheel found considerable favor.

The foregoing account, incomplete though it is, will be sufficient to show that there was considerable variation in the design and materials employed by the ancients in wheel-making. Even the wheels of the same country differed considerably among themselves. As early as 500 B. C., wheels had reached a very advanced stage of development even in Europe, owing partly to their use in war, partly to the sports of the Stadium, and partly to the rough roads and tracks they had to traverse.

(To be continued.)

## Condiments and Stimulants

### They Represent Lubricants, Not Motive Power

THE Pure Food and Drug bill, whose supporters have just scored so notable a victory over their opponents, includes in its provisions a number of alimentary articles whose freedom from contamination or adulteration is of peculiar importance from the fact that they contain very powerful drugs, though they are commonly regarded as mere table luxuries. We refer to those condiments and beverages which, though chiefly or entirely non-nutritious in themselves, are highly prized and almost indispensable additions to the daily fare among all grades of society in all civilized countries.

These consist mainly of various condiments of agreeable flavor and pungency and of the alcohols and alkaloids which in diverse degrees of dilution and modification are universally used as beverages. The former, though classed under the general head of spices, cover a very wide range, from hot and biting substances, such as pepper, mustard and pimento, through the strongly pungent and aromatic products of the clove and nutmeg to the fragrant herbs of the kitchen garden and the plants of delicate exotic flavor, like vanilla and cinnamon.

Alcohol is consumed as a table beverage chiefly in the form of light wines and malt liquors such as beer, ale, and stout, and the common alkaloids are the caffeine of coffee and tea and the theobromin of chocolate, if we exclude nicotine from consideration.

The comparatively modern science of physiological chemistry has devoted much attention to these substances in the effort to determine their precise effect on bodily functions and their potential value or harmfulness. Are they mere extravagant luxuries, not only useless but actually injurious to the human organism? Or do they have under proper circumstances a definitely beneficial effect?

Modern physiologists very generally declare in favor of the latter view, subject to certain restrictions. The eminent authority Puttenkofer sums the matter up very neatly by saying such things are "like the oil to a machine—they can't take the place of the steam that drives it, but they can make the action smoother and the running better. Only the oil must not corrode the machine!"

Here we have the crux of the matter. The healthy body may be able to make use of minute quantities of stimulants at moderate intervals without harm and even with benefit. But if the doses be too large or too frequent, a toxic quality manifests itself, or if the machine be already injured or weakened—i. e., if organic trouble exists—an extra strain is put on deteriorated tissues which they are unable to support. Hence the doctor's commands to give up coffee, wine, tea, or tobacco.

The value of the ailments under consideration is due to the property they possess of stimulating the nervous system, accelerating the heart action, and inducing a greater flow from the secretory glands, including those in the alimentary canal. Thus digestion is assisted and metabolism or tissue change is hastened. Every one is familiar with the way in which pungent aromas will cause the mouth to water or even the tears to flow, and other glands are similarly affected. Some authorities declare also that the nervous stimulus extends to the brain, causing increased cerebration, but with the curious limitation that this mental effect is confined to an increased activity of the emotions and passions and not of the reasoning faculties.

Such observations go far to explain the enormous valuation put upon spices in the middle ages, when "as dear as pepper" became a proverb, and when the trade in "Orient spices" made many a merchant of Venice and other commercial communities enormously rich. Indeed, this was one of the chief lures that led Columbus to the West Indies in his search for an easier route to the treasures of the East Indies.

Spices and condiments owe the physiological effectiveness noted above mainly to the etheric oils

they contain, and it is such oils that largely give the bouquet to wine and the aromatic bitterness to beer and ale. Such oils are prone to undergo a change, the molecule undergoing a progressive modification with the lapse of time, a slow oxidation taking place. This is why the bouquet of new wine differs so markedly from that of properly matured wine, the latter products being not only more agreeable in odor and taste, but less violent in their action on the nerve tissue. In all alcoholic drinks, however, the alcohol itself is the main factor of nervous disturbances, though the effect may be heightened by the addition of aromatic and even toxic substances, such as the anise-seed, kummel, fennel, etc., used in the manufacture of liqueurs.

It is needless to dwell here on the well-known effects of alcohol and the medical, social, and political controversies concerning its use and sale.

We pass on to a consideration of the alkaloid beverages, which include not only coffee, tea, and cocoa, but vast quantities of so-called "soft drinks."

The latter are supposed to be innocuous compounds of carbonated water, phosphates, lemon juice, fruit syrup, and the like, and their use is especially prevalent in America, where they are consumed in enormous amounts in city and in country by all classes of the population, and by children as well as adults.

It is authoritatively stated that 70,000 kilogrammes of caffeine are annually imported into the United States from Europe for use in these drinks. Ironically enough, this drug is extracted from coffee to render it a less injurious beverage!

Thanks to the exhaustive experiments of the celebrated German chemist, Dr. Emil Fischer, and other investigators, both the chemical structure of caffeine and its physiological action are now well understood. Caffeine and thein (the alkaloid of tea) are practically identical, so that the term caffeine may be used indiscriminately for the potent principle of coffee and tea. The bromin, however, the active alkaloid of cocoa or chocolate, differs in structure and is milder in effect.

Both caffeine and theobromin, according to Fischer, are derivatives of xanthin, which is in turn derived from uric acid, from which all three can be made synthetically.

The parent compound, xanthin, has no deleterious action on the fibers of heart-muscle; but when certain definite chemical groups enter the molecule—the so-called methyl groups—there is at once a marked effect on the contraction of heart muscle. The more methyl groups there are, the stronger this action; this is why cocoa and chocolate are milder than tea and coffee, since theobromin has but two methyl groups, and caffeine has three.

By passing through the body these compounds are broken up and the methyl groups to which the physiologic effect is due disappear, so that in the urine the caffeine has again become xanthin. Both caffeine and theobromin increase the excitability of the central nervous system and the potential of muscular energy, while at the same time lessening the feeling of fatigue. Used excessively, caffeine shows distinctly toxic effects. Five or six tenths of a grain are sufficient to cause sleeplessness, dizziness, muscular tremors, and even a tendency to vomit. The nerves and nervous system of the heart are specially affected, and there is a tendency to arterio-sclerosis from the abuse of caffeine. Since a single cup of coffee contains a tenth of a grain or more of caffeine, it is easy to see how readily confirmed coffee drinkers may overstep the bounds of safety. Caffeine also interferes with the digestion of the albumens which are so vital an element of sustenance. Although tea contains two or three times as much of the alkaloid as coffee, a cup of one contains about the same percentage as a cup of the other, owing to the different method of preparation.

Though theobromin, as we have said, is much milder of action, it is possible for an excessive use of choco-

late to be injurious. An investigator who consumed 100 grains per day for ten days found himself affected by trembling, pallor, sweating, and headache.

In view of these facts, it is advisable that both tea and coffee should be drunk in moderate quantities by adults and not at all by children, and that all soda fountains should be strictly supervised by boards of health with special reference to the employment of caffeine, saccharin, synthetic ethers, and other powerful drugs.

Herr Victor Graft of Vienna, from whose paper in *Prometheus* we have borrowed much of the data used in this article, is of opinion that the beverages we have been considering might be "depoisoned" in large measure by special processes which would eliminate wholly or largely the toxic constituent while leaving unimpaired the delicate and agreeable flavors and aromas to which, he believes, the pleasure of imbibing these drinks is due. Such a process for treating coffee has already been patented by Wimmer of Bremen, in which the caffeine is extracted by benzine, the claim being made that the coffee retains its aroma unimpaired. Graft makes the point that the flavors, and even the physical effects, of tea and coffee are largely dependent on other factors than the content of alkaloid. Much of the harmlessly stimulating effect of coffee, he says, as well as the aroma, proceeds from the "coffee oil" brought out by roasting, while tea contains, besides them, not only tannin, but etherical oils formed during the preparation of the harvest by a sort of fermentation, as well as special perfumes added by the Chinese. Attention is specially called to the circumstance that these drinks enable us to absorb agreeably the large quantities of water which the body has need of when undergoing strenuous exertions. Furthermore, while not themselves nutritive, they become the vehicles for nutritive matter in the shape of the milk, cream, and sugar added to them.

### Speed Measurement in Zeppelin Dirigibles.

THE speed of the Zeppelin dirigibles, "Schwaben" and "L. Z. IX," is measured by a special device which consists essentially of a Pitot tube connected to a water gage. This gage is composed of a glass bell-jar plunged into a receiver containing alcohol, alcohol being used because this liquid wets glass perfectly. The bell-jar is attached by a silk thread to a spiral spring, which supports it. Between the spring and the bell-jar the silk thread is wound on a pulley, keyed on an axle to which is affixed a needle moving over a dial whose surface is divided into volt-millimeters indicating water pressure.

Under the bell-jar is the end of a tube communicating with the plus branch of the Pitot tube, which is placed 3.4 meters (11.15 feet) below the car of the airship; the free surface of the alcohol is subjected to the pressures of the minus branch.

On board the "L. Z. X." ("Schwaben") a speed of 19.36 meters per second (42 1/3 miles an hour) was indicated with a development of 454 horse-power (the forward motor having 148 horse-power, and each rear motor 153 horse-power). With 290 horse-power (the rear motors making only 1,100 R. P. M. and the forward motor not running) the speed was 16.63 meters per second (36 1/3 M. P. H.). With 136 horse-power (the forward motor making only 980 revolutions and the two rear motors being stopped) the speed was 11.3 meters per second (24 1/4 M. P. H.).

The object of these experiments was not to indicate the exact speed of the dirigibles to the tenth of a meter per second, but to enable one to calculate, on the basis of known speeds obtained under known conditions (temperature and atmospheric pressure) the resistance to advance of the dirigible itself and its efficiency.—*Aerophile*.

### Electric Burns and Their Treatment.

The increasing application of electricity for domestic, public, and manufacturing needs, has led to a widespread prevalence of accidents from this source. These accidents consist of more or less serious cases of shock, and of localized burns caused by contact with an electric current.

Such burns are usually on the upper part of the body, especially the head, arms, and hands, since they are commonly occasioned by the fall of a wire or the chance touching of a highly charged piece of metal when mounting a ladder.

They present marked clinical peculiarities both of aspect and of evolution, and the treatment correspondingly varies somewhat from that of ordinary burns.

According to the *Presse Medicale*, electric lesions are differentiated from the former in three ways—first, by their aspect and development; secondly, by their "indolence," or non-painful character; and thirdly, by being completely aseptic.

Superficial electric burns are rare; they do not attack the dermis, do not show the inflamed edge of ordinary burns of the second degree, and unlike these do not exhibit phlyctenae till the fourth or fifth day.

Deep burns are more frequent, because the extremely high temperature developed at the point of contact of the current causes the destruction of a solid mass of flesh and the carbonization of tissues to a considerable depth. Hence there is a complete loss of substance, a lump of dead matter being surrounded by healthy tissues without any intervening transitional territory.

On the head, where the bone is less protected than the skeleton in other parts of the body, the bone is often involved. Usually the resulting osseous necrosis is confined to the upper layers, however; and since the cerebral organs are protected by the inner layers, the prognosis is apt to be favorable, even when the injury is of considerable extent. When the necrosis affects the entire depth of the skull, on the contrary, cerebral and meningitic complications are to be feared.

The second characteristic of electric burns, their "indolence," is perhaps the most specific and the most unexpected in view of the violent pain associated with ordinary burns. This symptom is almost constant, and is attributed to the destruction of the nerve terminations or to the aseptic evolution of the lesion. It is so definite that the wounded sometimes do not perceive that they have been hurt.

Finally there is complete asepsis: there is no inflammatory reaction, suppuration is lacking, the carbonized tissues are eliminated little by little without infective phenomena. This is due to thorough sterilization of the mass of tissues by the high temperature produced at the current's level of penetration. Superficial burns are quickly cicatrized, showing a moist and supple scar not at all like that of ordinary burns. Deep lesions generally heal easily, leaving after the fall of the rough scar a surface of a bright red, without hair. They are sometimes, however, very slow in healing, where the loss of substance is very great, and especially if the bone is involved.

Besides the absence of infection there are lacking other features (shock and visceral congestions and thromboses) which so frequently cause dangerous complications in ordinary burns. On the other hand, electric burns frequently cause local nervous complications, such as neuritis, muscular atrophies, and vasomotor troubles.

The treatment is very simple: it consists chiefly in maintaining the asepsis; only the concurrence of a bony lesion sometimes demands active intervention.

It is a well-known fact that instantaneous deaths are due to currents of moderate voltage (500 to 600 volts), while those of high potential (2,000 volts and over) produce generally a loss of consciousness which yields to artificial respiration. In fact, Besson has collected a number of instances in which individuals survived who had been subjected to the passage of currents of from 2,500 to 4,500 volts.

This is owing to the fact, established experimentally, that the moderate voltages throw the cardiac muscle into a state of fibrillary tremulation, while high voltages have no direct effect upon the heart, but inhibit the center of respiration; consequently a certain duration of time is required for the latter to produce the secondary arrest of the heart which results in death.

Hence the comparative harmlessness of high potentials is very explicable; there are at the point of contact local phenomena produced which modify the local resistance in such manner that the current finds itself interrupted. The charred tissue forms a barrier which interrupts the action of the electric energy before the respiratory arrest becomes final, and the injured man may be saved by prompt and energetic restorative measures. This explains the many cases in which individuals who would have been killed by currents of four or five hundred volts, may escape with a temporary loss of consciousness and a few insignificant burns after being exposed for several minutes to the passage of a current of high voltage.

### Rules Governing the Competition for the \$15,000 Flying Machine Prize Offered by Mr. Edwin Gould

1. A PRIZE of \$15,000 has been offered by Mr. Edwin Gould for the most perfect and practicable heavier-than-air flying machine, designed and demonstrated in this country, and equipped with two or more complete power plants (separate motors and propellers), so connected that any power plant may be operated independently, or that they may be used together.

#### CONDITIONS OF ENTRY.

2. Competitors for the prize must file with the Contest Committee complete drawings and specifications of their machines, in which the arrangement of the engines and propellers is clearly shown, with the mechanism for throwing into or out of gear one or all of the engines and propellers. Such entry should be addressed to the Contest Committee of the GOULD-SCIENTIFIC AMERICAN Prize, 361 Broadway, New York city. Each contestant, in formally entering his machine, must specify its type (monoplane, biplane, helicopter, etc.), give its principal dimensions, the number and sizes of its motors and propellers, its horse-power fuel-carrying capacity, and the nature of its steering and controlling devices.

3. Entries must be received at the office of the SCIENTIFIC AMERICAN on or before June 1st, 1912. Contests will take place July 4th, 1912, and following days. At least two machines must be entered in the contest or the prize will not be awarded.

#### CONTEST COMMITTEE.

4. The committee will consist of a representative of the SCIENTIFIC AMERICAN, a representative of the Aero Club of America, and the representative of some technical institute. This committee shall pass upon the practicability and efficiency of all the machines entered in competition, and they shall also act as judges in determining which machine has made the best flights and complied with the tests upon which the winning of the prize is conditional. The decision of this committee shall be final.

#### CONDITIONS OF THE TEST.

5. Before making a flight each contestant or his agent must prove to the satisfaction of the Contest Committee that he is able to drive each engine and propeller independently of the other or others, and that he is able to couple up all engines and propellers and drive them in unison. No machine will be allowed to compete unless it can fulfill these requirements to the satisfaction of the Contest Committee. The prize shall not be awarded unless the competitor can demonstrate that he is able to drive his machine in a continuous flight, over a designated course; and for a period of at least one hour he must run with one of his power plants disconnected; also he must drive his engines during said flight alternately and together. Recording tachometers attached to the motors can probably be used to prove such performance.

In the judging of the performances of the various machines, the questions of stability, ease of control and safety will also be taken into consideration by the judges. The machine best fulfilling these conditions shall be awarded the prize.

6. All heavier-than-air machines of any type whatever—aeroplanes, helicopters, ornithopters, etc.—shall be entitled to compete for the prize, but all machines carrying a balloon or gas-containing envelope for purposes of support are excluded from the competition.

7. The flights will be made under reasonable conditions of weather. The judges will, at their discretion, order the flights to begin at any time they may see fit, provided they consider the weather conditions sufficiently favorable.

8. No entry fee will be charged, but the contestant must pay for the transportation of his machine to and from the field of trial.

9. The place of holding the trial shall be determined by the Contest Committee, and the location of such place of trial shall be announced on or about June 1st, 1912.

10. Mr. Edwin Gould, Munn & Co., Inc., publishers of the SCIENTIFIC AMERICAN, and the judges who will be selected to pass upon machines, are not to be held responsible for any accident which may occur in storing or demonstrating the machines on the testing ground.

**International Telephone Lines in Europe.**—A bill concerning the establishment of telephone communication between Milan, Zurich, Basel, Frankfurt and Berlin has been passed by the Italian Parliament. The proposals for the new lines have to be ratified by the authorities in Germany, Italy, and Switzerland, but this is said to be a mere matter of form, and construction work may soon commence. The shortest course between the different places will be followed. The lines from Milan to Basel and from Milan to Basel and Frankfurt will probably pass, says the *Electric World*, through the Simplon and go via Lausanne, whence the shortest route will be taken to Basel.

### Science Notes.

**Japanese Arctic Expedition.**—The Japanese expedition in quest of the South Pole, which after reaching the point 74 degrees south last winter, was obliged to return on account of bad weather and ice packs, has started upon a second expedition. The *Kainan Maru*, which carried the expedition, has in the meantime been thoroughly repaired and equipped.

**Canadum, a New Metal.**—According to recent press report, Andrew Gordon French has discovered a new metal, belonging to the platinum group, which he has named Canadum. This metal was discovered in the Kootenay ores in Canada. Samples of the ore have been sent to a number of the leading scientific societies.

**Making Diamonds from Gas.**—According to a recent press report, Dr. Werner von Bolton, of Berlin, has discovered a process of making diamonds from gas. Ordinary illuminating gas is used and this is decomposed by means of a mercury amalgam, causing the carbon of the gas to crystallize into diamonds. The crystallized carbon is very fine, but it has been found that by introducing a small diamond chip in the apparatus the diamonds produced from the gas will be gradually built up around the mother crystal.

**Bees as a Medium of Sugar Inversion.**—Observations have shown that bees can fill up with a 50 per cent cane sugar solution within two minutes, and that it takes them just as long to discharge this solution into the cells. Within this short space of time, by a single passage of the solution through the honey-bag of the bee, 4/5 of the sugar has been inverted. If the centrifuged solution of sugar is allowed to stand for several days at ordinary room temperature, it will be found that all but one per cent of the cane sugar is inverted. Honey obtained by feeding bees with a solution of sugar (a method often employed in adulterating honey) can by mere external examination not be distinguished from the natural product. However, it does not possess a trace of the aroma of the latter, having merely a sweet taste.—*Apotheker Zeitung*.

**The Development of the Export of Air Saltpeter from Norway.**—The export of this article shows yearly a large increase, although the total quantities are not yet very large. According to the review given out by the Bureau Central de Statistique de Kristiania, the figures in 1000 tons of Norgesaltpeter in the years 1908-1910 are as follows:

Country to which exported.	1908.	1909.	1910.
Sweden .....	20.5	32	1.4
Denmark .....	538	256	392.2
Germany .....	3,841	4,803	4,791
Holland .....	1,270	1,149	1,687
Belgium .....	32	136	363
Great Britain .....	619	2,530	4,900
France .....	671	152	683
Spain .....	55.6	..	168
Italy .....	..	15	46
Ireland .....	..	250	200
Russia .....	..	21.5	100
Africa .....	5	12	..
U. S. of America .....	0.5	..	149
West Indies .....	..	2.2	10
Australia .....	..	7	39.6
Other countries .....	..	..	0.1
Total .....	7,052.6	9,365.7	13,530.3

The total export in 1910, therefore, amounted to 13,530 tons of saltpeter, of which Great Britain was the principal buyer, followed by Germany. All other countries use about one-half the amount exported to Great Britain and Germany. The price of Chile saltpeter has not yet been influenced by the importation of the air saltpeter.—*The Journal of Industrial and Engineering Chemists*.

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